TOWARDS AN EFFECTIVE MANAGEMENT STRATEGY FOR PASSIVE RFID IMPLEMENTATION

GRADUATE RESEARCH PROJECT

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Abstract

Over ten years after the lessons of the first gulf war had been absorbed and the Global Transportation Network was initiated, the DoD continues to struggle with tactical in-transit visibility. Now the DoD has mandated that the supply chain, including DoD vendors, apply a new and potentially revolutionary technology, passive radio frequency identification, to solve this problem. However, many issues central to passive RFID implementation remain unresolved. First and foremost, a comprehensive management strategy, including a complete redesign of business practices, must be developed. This research provides a framework for that management strategy and offers specific recommendations for top level management actions that must be accomplished to ensure passive RFID delivers on its promise of tactical in-transit visibility and revolutionary improvements in the supply chain.

Acknowledgments

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David Koch

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I. Introduction

Background

After a decade of critical analysis, Operation Desert Storm has proven to be one of the swiftest, most decisive military victories in recorded history. Even so, the Department of Defense (DoD) has acknowledged that, in addition to great leaps in technology, training, and operational doctrine, it also benefited from numerous blunders by the enemy, not the least of which was allowing the United States all the time needed for a full buildup of military capabilities in the theater of operations. But while the final outcome was decisive, the logistical support behind that outcome was grossly inefficient. War materiel measured in billions was lost, unaccounted for, and worst of all, never made it into the hands of the front-line units who needed it. Without the time cushion DoD enjoyed, these inefficiencies might have manifested themselves in ways that could have serious negative operational impacts far greater than the mere expenditure of additional dollars. It was clear that the technology and doctrine of logistical support had not kept pace with the needs of the modern war fighter.

Having recognized this, the Department of Defense (DoD) put a great deal of effort into analyzing the logistical breakdowns of the Gulf War, including evaluation and implementation of new technology and an attempt at a system-level architecture for tracking movement of war materiel. It was hoped that, when mature, the Global Transportation Network (GTN) would give everybody, from the stateside supply activity

to the requisitioning supply sergeant in the field accurate, real-time visibility of every item in transit.

Despite the DoD's best efforts, similar inefficiencies appeared during Operation Iraqi Freedom (OIF). The GAO reported a discrepancy of $1.2B between materiel requested, and materiel received, millions of dollars of late fees on leased containers, excessive and unnecessary cannibalization, and massive duplication of requisitions to compensate for lost materiel (Solis, 2003). One of the criticisms leveled by the GAO was the poor use of Radio Frequency Identification (RFID) technology.

Until now, most of the RFID experience, both in the DoD and the commercial sector, has been with active RFID systems. However, technological advances in both the cost and capability of passive RFID systems have made that technology more attractive. Wal-Mart, the world's largest retailer, has mandated that their top 100 suppliers attach RFID tags to all crates and pallets by January; 2005 (Kharif, 2004). Wal-Mart's near-monopsonistic purchasing power makes them primary driver of industry practices, and it is expected their mandate will accelerate two trends that need to mature for RFID to be a transformational supply chain technology: economies of scale that will drive down the cost of passive RFID tags to a widely useable level (Young, 2003), and finalization of digital protocols for generation and exploitation of RFID data (Boyle, 2003).

More recently, the DoD issued a policy memorandum requiring suppliers to employ passive RFID tags on at the lowest practical level (Wynne, 2004). While Wal-Mart's motivation is profit and the DoD's motivation is operational effectiveness, they both seek to do this in the same way: by ensuring customers have access to what they want, when they want it. For Wal-Mart, this customer is a shopper and for DoD, the

customer is a front-line unit that needs access to war materiel to prosecute the mission. Either way it all boils down to the core of the logistics function: providing time and place utility to the end user.

The DoD policy memo also directs the creation of RFID business practices to ensure full exploitation of the technology (Wynne, 2004). Like Wal-Mart, the DoD has surmised that this particular rapidly growing technology could greatly enhance operational effectiveness. However, the mandate to suppliers was put out well in advance of the development of these business practices, or even RFID architecture or acquisition and implementation strategies, and much work needs to be done if the new policy is to bear fruit.

Problem Statement

RFID technology has reached the requisite state of maturity and the policy mandating its use has been released. While it is easy for the DoD to make these demands of suppliers, it is far more difficult to ensure readiness to handle the data that will be available. The literature is replete with information technology failures. As many as 20 percent of information technology projects are abandoned, with most of those remaining failing to achieve either their full potential or all the goals of the implementer (Oliver, 2004). Furthermore, the DoD's current experience with active RFID systems is far from sterling. So, while the DoD is seizing an opportunity to capitalize in information technology growth, they must begin by making some high-level decisions about how they will define, acquire, implement, and manage the system to maximize operational effectiveness.

Research Question

The focus of this research is to answer the question: How should active RFID experience be applied toward an appropriate management strategy for passive RFID implementation?

Investigative Questions

To answer the research question, this research will address the following investigative questions:

1. How has active RFID technology been applied in the DoD thus far?
2. What lessons can be drawn from the experiences of those engaged in active RFID use?
3. What current DoD transportation management systems have the capability to handle passive RFID data?
4. What operational/performance factors drive the use of passive or active RFID systems?
5. What are some of the challenges to integrating passive RFID in the DoD?
6. What management strategies provide useful inputs for development of a management strategy for passive RFID?

Research Objective

The primary objectives of this research are two-fold: to identify lessons learned from active RFID use and to evaluate the myriad reasons information technology projects succeed or fall short of their goals. Once these elements are identified, the research will synthesize the lessons learned and information technology management theory to produce

a useful management construct for the successful acquisition and implementation of passive RFID technology for use in the DoD.

Scope and Limitations of Research

This premise of this research lies in the DoD's decision to mandate passive RFID use prior to engaging in a full review of the technologies' capabilities, costs, and changes that may be necessary in its supply chain business practices to fully realize the potential benefits. Since the DoD has already placed a demand for the "cart," this research aims to lay the groundwork so the DoD can properly spec the "horse."

Given the current state of the DoD's involvement with passive RFID, it is necessary to focus on the management constructs required to maximize the return on investment from passive RFID. This research is squarely focused on identifying those management constructs; at no time will any specific technical solutions for passive RFID implementation be offered.

Data collected for the literature review and to address investigative questions one through three will come from current literature and unstructured interviews. Sources for the interviews include DoD RFID senior program managers and industry experts. While there are certainly more subject matter experts who could provide information on active RFID experience, these few provide adequate fidelity for this research.

While there is substantial quality research available regarding active RFID, the newness of passive RFID creates a lack of such research. Consequently, data sources for passive RFID will be primarily from current trade journals, news reports and briefings.

There is also a wealth of data available regarding the success and failure of information technology projects. This analysis will focus on published research and scholarly texts.

Methodology

This research will be a modified case study approach. First, this research will focus on DoD experience with active RFID. This research will provide the lessons learned from the DoD's first attempt at exploiting RFID technology. The problems and/or success encountered in this effort will help lay the groundwork for developing a management strategy for full implementation of passive RFID. The study will utilize parts of the GeoBase Sustainment Model, established by Cullis (2003), as an initial framework to develop a passive RFID implementation model. There is a wealth of data available, mostly in the form of academic research, detailing the management of this large-scale Air Force information technology project. While not without its hiccups, GeoBase implementation was, by most measures, a successful information technology effort affecting a large variety of widely dispersed users, and provides a case similar enough to RFID to effectively support this research.

Given the tremendous amount of research available regarding what leads to successful or unsuccessful information technology implementation, this research will survey various prescriptions for successful information technology implementation. It is hoped that this will allow the development of an appropriate management construct that fits the DoD's culture, its requirements for RFID, and the capabilities of the technology itself.

Chapter Summary and Preview of Remaining Chapters

This chapter provided the background for this research, defined the problem, outlined the research and investigative questions, and provided an overview of the scope and limitations of the research and the methodology to be employed. The DoD has mandated passive RFID use prior to articulating just what is to be gained and how. This qualitative research use a modified case study approach to examine active RFID lessons learned and management strategies for information technology implementation to arrive at an appropriate management construct for passive RFID.

Chapter two will provide a literature review concentrating in two areas. First, literature covering RFID capabilities and employment to date, both in the DoD and the private sector, will be covered. Second, the literature review will focus on published academic material pertaining to management of information technology implementation.

Chapter three will give a more detailed description of the methodology chosen for this research, why it was chosen, and how data was gathered and analyzed.

Chapter four will provide the analysis of the data with emphasis on answering each of the five investigative questions.

Chapter five will provide the final conclusion in the form on an answer to the research question. It will also address specific limitations of the research and recommendations for future research.

II. Literature Review

Introduction

To develop theory towards the successful implementation of passive RFID in the Department of Defense, information on associated topics must be reviewed, analyzed, and synthesized. The purpose of this chapter is to review the relevant literature regarding active and passive radio frequency identification technology and pertaining to the successful implementation of large scale information technology to develop a management strategy for implementation of passive RFID in the DoD.

This chapter will first review appropriate literature describing RFID and its capabilities. It will review DoD experience with RFID, to include lessons drawn from the use of RFID in Bosnia and Operation Enduring Freedom. In addition, it will review lessons learned from commercial implementation of RFID. Then the review will focus on management strategies for successful implementation of large scale information systems, reviewing tested procedures for global information system implementation.

Radio Frequency Identification (RFID)

Introduction.

RFID falls under the larger umbrella of technologies known as automatic identification technology (AIT). AIT is a general term that characterizes several different methods of identifying assets through automatic means. Examples of AIT include barcode systems, smart cards, optical memory cards, magnetic stripe cards, magnetic storage media, optical character recognition, satellite tracking technology, and RFID ("Air Force", 2001).

The term Radio Frequency Identification (RFID) describes the use of radio frequency signals in the automatic identification and tracking of objects through the use of a “tag” that sends data to readers through wireless communication. An RFID system utilizes tags to “speak” about the identity, location, activity or history through readers and software that processes, and ultimately uses the information (Highjump Software, 2004). It is a flexible technology that is not only easy to use, but is extremely well suited for automatic operation (Richter, 2004). When attached to pallets, cases, or individual supply products, the RFID tags provide manufacturers, distributors, and retailer’s incredible control over their logistics operation. This information could help businesses make better and faster decisions, which could increase efficiency and productivity. For example, an RF tag on a pallet being unloaded in a retailer’s warehouse could initiate an electronic payment to the shipper and eliminate the need for creating an invoice (Ewalt, 2002).

As depicted on the next page, RFID systems are composed of four main components, to include an interrogator, a transponder, an antenna, and a host system (Microlise, 2003). An interrogator, more commonly called a reader, is a device used primarily to read and write data to RFID tags (Richter, 1999). The reader receives the RF transmissions from the tag and passes the data to a host system for processing.

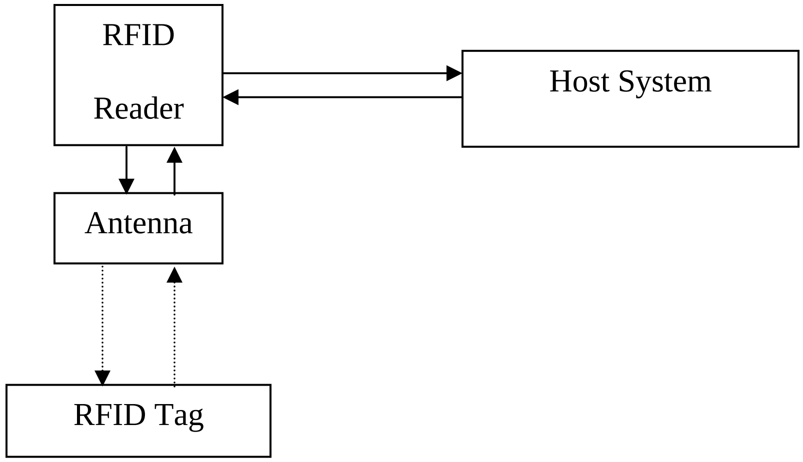


Figure 1. The RFID System (Adapted from Microlise, 2004).

RFID Tags.

Tags are generally classified into two main categories: active and passive. Passive tags do not contain an internal power source such as a battery and are relatively inexpensive to manufacture. The passive tags operate when the electromagnetic energy is radiated by an interrogator to power the RF integrated circuit that makes up the tag itself. Some more advanced passive tags do contain a small battery source. Active tags contain both a radio transceiver and a battery to provide power. The internal radio on the tag provides a much larger range than passive tags, but at a considerably higher cost (Richter, 1999).

Tags also come with two different kinds of memory components. A read only type tag is programmed in the factory and cannot be changed after the manufacturing process. The read and write memory can be altered by the transponder. It can be read and encode data. Read only tags are significantly less expensive than read and write tags, but the cost of both tags have come down considerably, as will be discussed later in this paper. Low cost RFID tags can be applied in new and innovate ways that are of great

interest to suppliers and end users.   The tags are better than the barcode or magnetic stripe on a printed label because they are more resilient to mis-orientation and obscuration. In addition, they are inexpensive enough to be disposable and thin enough to be placed in small locations—inside sheets of paper in some cases. In fact, the tags have become so flat that they are often referred to as smart labels (Das, 2002).

RFID Antennas.

RFID systems usually include at least one antenna to transmit and receive the data signals. Some systems include antennas that transmit and receive, while other systems utilize a separate antenna for each process. Antennas differ depending on the type of application of the RF system and the frequency utilized (Intermec, 2001).

RFID Transceiver.

The RF transceiver or reader is the source of energy to activate and power the passive RFID tags. The transceiver can be a separate piece of equipment, or it can be co-located with the reader. The transceiver controls the RF signal emitted by the antenna and filters the signal from the passive RFID tag. RFID generally operates in two different frequency ranges depending on the use of the system. For example, for smart card type application, the system should not be inadvertently activated beyond one meter, so 13.56MHz provides the near field read and write capability.   For item management applications, it is more ideal to have far field capable technology, which is usually provided by a 2.45 GHz or 915MHz system. The specific problem that the RF system is solving dictates the appropriate frequency range to employ (Intermec, 2001).

Capabilities.

There are many advantages to fully operational, integrated RFID systems (Caltagirone, 2004). Some of the possible applications include: electronic toll collection, railway car identification and tracking, inter-modal container identification, automobile security, access control to facilities, item management for logistics or retail, asset tracking and identification, to name a few (Richter, 1999). This research concentrates on successful implementation within the Department of Defense. However, RFID technology, in general, has numerous advantages that apply to many of the possible diverse applications of this technology. The following are some of the advantages of this type of system:

- It is not line of sight technology: RFID tags do not have to be visible to the interrogator to work accurately.
- Tags can withstand harsh environment (Intermec, 2001).
- Tags can withstand heavy vibration and shock because they are solid state technology (Richter, 1999).
- The tags are reusable (Richter, 1999).
- Many tags can be read simultaneously—up to 200 at a time accurately (McCall, 2004).
- Data is secure because it can be locked once written to the tag (Richter, 1999).
- Preventing shoplifting; RFID can be used in conjunction with security detection systems in stores to alert employees when someone leaves the store with a tagged item potentially solving a $53 billion per year problem (Want, 2004).
- Instantaneous inventory updates (Caltagirone, 2004).

Table 1 shows specific attributes of various RFID tags.

Table 1: RFID Tag Attributes

Manufacturer	Active or Passive	Line of Sight Requirement	Read/Write Capability	Memory Size	Range
ASGI	Passive	Yes	Yes	115 Bytes	<2.5 m
AT/Comm	Active	No	Yes	10 Kb	>2000 ft
ID Systems	Active	No	Yes	64Kb	50 m
Intellitag	Passive	No	Yes	2Mb	>10 m
Rand Technologies	Active	No	Yes	128Kb	150 m
Saab Scania Combitech	Passive	No	Yes	8Kb	>10 m
Savi Technology	Active	No	Yes	128Kb	150 m
Single Chip Solutions	Passive	Yes	Yes	1Kb	<2 m
Texas Instruments	Passive	No	Yes	512Kb	<2 m
XCI	Passive	Yes	No	26 bits	10 m

(Gross, 1995)

DoD Applications.

RFID has numerous possible applications within the DoD, and many applications are related to solving the problem of "uncertainty in the supply chain." One significant problem that logisticians are particularly interested in solving is the ability to track inter- and intra-theater shipments of military equipment loaded in containers. Defined by United States Transportation Command (USTRANSCOM) as In-Transit Visibility (ITV), it refers to the ability to track the status, identity, and location of cargo and passengers from origin to destination during times of peace and war (Method, 1998). Operation Desert Shield and Desert Storm highlighted the incredible problem that DoD has in tracking shipments. It is reported that as many as 20,000 containers of military equipment (about half of the total shipped) had to be opened, inventoried, and re-entered

into the transportation system because the contents of the container were unknown (Method, 1998). The DoD lacked the technology to adequately track container contents at that time.

In addition to the ITV problem, DoD is interested in solving several other related problems. Poor documentation and inventory control plagues the DoD system. It often takes too long from the requisition request until the item is received. In addition, lack of certainty in the current system breeds multiple requests for the same part. Currently, the lack of adequate tracking leads to backlogs at distribution points. If these processes were automated with RFID technology, the problems could be solved. For example, North American railroad decreased their off-load/on-load time from one and half hours to 20 minutes using RFID technology (Gross, 1995). A study conducted in 1992 by Logistics Management Institute for the DoD concluded that Defense Logistics Agency (DLA) could save $5.5 million a year if RFID tags were used to provide instant recognition of products and automatic collection of item-specific information on hazardous materials (HAZMAT) as they travel through the supply stem (Vandenberghe, Balkus, & Kordell, 2002).

Current RFID Issues.

RFID will potentially solve many problems in civilian industry and in the DoD, but there are several stumbling blocks currently slowing down the process. In addition, there are a couple of issues that RFID creates. Microlise (2003) outlined several drawbacks to current RFID implementation. First, the price of tags is still high—depending on the whether or not the user needs active or passive tags. Second, the read/write range can limit the application. Third, the world-wide standards are still under

development. Finally, RFID reads are not quite 100 percent yet, so non-reads must still be dealt with accordingly (Microlise, 2003).

In addition to a few issues slowing down the full implementation of RFID, the technology creates a major social issue that must be explored—how to protect privacy of the public. With the goal of everything being eventually tagged and RFID readers widespread, it would be incredibly easy to track personal information on people. Wal-Mart and Benetton both canceled large-scale tests of in-store RFID technology due to public reactions to wholesale monitoring of citizens through embedded tags on products. Another major concern is that RFID tags identifying individual items purchases with credit or debit cards could be linked by the card’s or stores databases. Stores could track exactly what clothes you are wearing, where you bought them, how much you spent, etc. In the hands of marketers, the information could be used for targeted sales pitches by phone or direct mail. Unfortunately, there is no easy solution to this problem (Want, 2004).

Another problem is that RFID produces a readily available audit trail of commercial transactions. In a totally tracked world, people would know if you lied about how or where you spent your time or money. This could have significant consequences for the workplace, legal system, and potentially the courtroom. Could an RFID log be submitted as evidence? Who should be entitled to the transaction logs and for what purposes? All these issues need to be addressed. A related concern focuses on the security of RFID coded information. Karlen (2002) addressed the issue of access to information maintained in RFID tags and recommended public key security as a viable method for ensuring RFID coded information is restricted to those with a need to know.

One final issue is the eventual displacement of workers due to RFID systems. Significant opposition to tagging should be expected from the industrial labor force, which will likely lose significant numbers of jobs as computers begin to perform tasks that are now accomplished by humans. Issues such as these have caused bitter strikes in the past and should be expected from labor unions (Want, 2004).

DoD Experience with RFID.

Several studies have been accomplished that have investigated possible application of RFID technology in the DoD. Gross (1995) studied the lack of asset visibility problem in Operation Desert Storm and recommended using RFID systems to track the movement of 463L pallets worldwide. He analyzed the purchasing a commercial off-the-shelf (COS) system produced by Amtech Corporation. He projected that DoD would need to invest $77 million to gain this initial capability, but projected that direct cost savings to core operations would nearly mirror the cost of the system purchase and upkeep. He recommended that the DoD consider waiting until the cost of systems decreased and the improvement in the RFID systems improved prior to making the investment. However, the DoD began investing in active RFID systems within a few years of his study.

In a 1998 thesis, Capt Leigh Method compared timelines for transportation of RFID enabled and non-RFID enabled cargo from the point of origin to its final destination and found a statistically significant difference. Surprising and disappointing was that the RFID tagged cargo actually spent *longer* in the transportation pipeline (Method, 1998). Capt Method gave a number of possibilities for these surprising results. First, the technology was new and the technicians on the ground were probably not

proficient with the “new system” yet. Second, tagged and non-tagged cargo were transiting the same ports, so the tagged cargo needed extra processing to get through the port. For efficiencies to result, the cargo needs less processing, vice more processing. Finally, the technology in this study was not intended to benefit the processing nodes. It was designed to benefit the customer and provide better ITV on the cargo movement. In addition to the theories offered by Method (1998), this project suggests that that the technology was poorly integrated, both in terms of how it was incorporated into business practices and the familiarity of the troops who were required to apply the technology.

Burns (2002) continued Method’s (1998) research, but recommended that RFID technology be utilized to track munitions. He concluded that total asset visibility (TAV) will never become a reality without RFID. Although RFID technology may seem expensive, the hidden manpower costs of maintaining ammunition tracking without it are three times as expensive. He concluded the DoD decisions makers should pursue the technology as soon as possible.

The DoD has taken steps to implement active RFID systems on 463L pallets traveling into and out of the theaters of operations. Operation Enduring Freedom has put these new systems to the test. The question is “have they worked” and if not, “why not”. A recent Government Accounting Office (GAO) report revealed that hundreds of containers and pallets of war material were backlogged at distribution points due to inadequate visibility. The report discussed duplication of requisitions and circumvention of the supply line due to the ITV system failures.

Subsequent literature has pointed a number of root causes for DoD’s failure to maximize the benefits of RFID technology; most of them boil down to training and

integration issues. According to Captain Tom Neff, assistant product manager for radio frequency in-transit visibility, “A lot of locations have never really heard of RF technology until they were deployed to the Gulf” (Chisholm, 2003). The totality of the lack of training and exercise is most clearly illustrated by the fact that much of the RFID equipment was simply left in the OFF position (Kimball, 2004) Obviously, a great deal of training is necessary to bring a system like this on line. This training goes far beyond just teaching personnel the ins and outs of the system, but it must also include intensive training in wartime scenarios. DoD must exercise the system or “Train like we fight.” Failure to do in peace what must be done in war was identified as a critical lesson from the field in terms of RFID application (Carpenter, 2003). In fact, RFID has not been instituted in stateside transportation systems, so how can DoD expect troops to know how to use it overseas, especially in austere conditions?

Ritter (2004) reported that although the instructions directed that assets were not to be shipped into the theater without active RFID tags, many were shipped without tags. Thus, ITV was significantly hampered. Ritter (2004) concluded that RFID technology, if robust and properly implemented, holds the most promise for overcoming the cargo processing challenges in ports. He recommends that a combination of active and passive tag systems could potentially be utilized, but recommended a thorough scrub of DoD business processes first (Ritter, 2004).

Ongoing RFID initiatives.

Many companies are pursuing initiatives with RFID and this section will discuss three of them. Yellow Corporation, one of the nation’s largest trucking firms for less-than-truck-load transportation, has recently demonstrated an RFID application. The

company set up a dock door with portal readers. When tagged cartons are pushed through the dock, the inventory is automatically updated at a mock distribution center. They recently demonstrated this process at a Transformation Conference attended by 1800 Yellow customers. Although the company currently tracks all their packages through bar codes, they believe that RFID will be much more efficient once fully implemented. Externally, RFID would provide more visibility of shipments to the customers. Internally, it will improve management of the transportation network within the company (RFID Journal, 2003b).

Wal-Mart recently announced that it will require its top 100 suppliers to place high frequency passive tags on all cartons and pallets shipped to Wal-Mart's stores by 2005. Their goal is to develop behind the scenes RFID capabilities in their warehouses which they feel will offer significant cost savings with a minimum investment (Want, 2004). The Wal-Mart requirement is extremely important because it will create a cascading demand for RFID tags and the hardware and software needed to run the systems. If Wal-Mart deploys the system and shows excellent results, the market will really open up (Ewalt, 2002).

Recent RFID advances.

Before RFID systems can become widespread, several key issues must be solved. The two most often cited are the cost of tags and the lack of RFID standards. Tag prices for "chip" tags have come down considerably and are even available for less than 50 cents if purchased in large quantities (McCall, 2004). "Chipless tags" are as cheap as 1 to 2 cents a piece, but they cannot hold much data (Das, 2002). The recent ISO 15693 specification for RFID systems utilizing the HF frequency range will help the

standardization process, while the UHF frequency standard is expected within the next three years (McCall, 2004). In addition to improvements in regards to price and standards, several other recent advances will are worth noting. First, RFID passive tag systems can now communicate up to 20 feet with improved antennas. This improvement allows for cargo to be loaded or unloaded from trucks without ever manually scanning the boxes. Second, improved anti-collision algorithms allow over 200 tags to be read at the same time, which allows forklift drivers to drive a fully loaded pallet by a reader without needing to slow down. Finally, tags no longer suffer from the "poor orientation" problem due to improved 3-D antennas. This technology has made the RFID tag system much more reliable (McCall, 2004).

As DoD experience with RFID increases and advances are made in the technology, especially in the area of integration, new possibilities are opening up. Chisholm (2003) noted that the integration of RFID with GTN and Joint Total Asset Visibility (JTAV) data is beginning to approach the sort of information requirements necessary for combatant commanders to make informed decisions. Carpenter (2003) took that concept a step further by suggesting the integration of RFID with additional logistics information systems including the Global Air Transportation Execution System (GATES), Standard Army Retail Supply System (SARSS), Surface Transportation Management System (STMS), and the Movement Tracking System (MTS).

It is worth noting at this point what the literature lacks: extensive discussion of how active and passive RFID can work together effectively in an integrated system. Most of the commercial literature all refers specifically to either active or passive RFID. The balance refers to RFID in generic terms without specifying active or passive. Only

one speculative DoD briefing provides an indication of how the two may work together. This is a hole in the literature as discussion of one or the other in isolation fails to fully realize the possible benefits. Discussion of RFID in general terms is especially lacking: as already noted, the two technologies vary specifically, and as will be demonstrated in chapter four, these differences bear significantly on how the technology may be applied.

Summary

Implementation of effective RFID systems should significantly decrease the uncertainty in the supply chain as it revolutionizes the transportation industry and supply chain management business through paperless, error free, and efficient tracking of goods. These efficiencies may serve as a force multiplier for the DoD who has a history of mediocre tracking of supplies during peacetime and war. With the current explosion of interested parties, rapid movement along learning curves for production and implementation, dramatic cost reductions, and numerous industries rapidly taking advantage of RFID, the DoD stands ready to take advantage of the technology in ways not yet realized. However, information technology implementations are not easy to accomplish, especially on the scale the DoD will need for RFID. To establish an effective RFID program, a proper management strategy must be established and followed. This strategy will need to evaluate the current DoD issues with implementation of active RFID tags, carefully consider IT implementation issues, and enumerate a workable plan. The following section will detail the DoD's mandate to implement a passive-tag RFID system.

DoD RFID Mandate

The DoD is committed to being an early adopter of passive RFID technology. There are several problems that the DoD hopes to solve, all relating to uncertainty in the DoD supply chain, such as lack of customer confidence, lack of consistent information, unsynchronized material flow, and lack of collaboration in planning and execution (Stewart, 2004). Although DoD already operates the largest end to end active RFID system in the world … 30 countries and 850 sites world-wide … they currently only have "islands of RFID capability". The near term plan for DoD is to immediately implement RFID to support the Combatant Commander for ITV purposes. To accomplish this, the DoD is requiring active RFID tags on consolidated sustainment and ammunition containers, Air Force pallets, unit moved equipment, and pre-positioned material and supplies.

Simultaneous to the active RFID requirement, the DoD is establishing a RFID infrastructure to support core business processes and budgeting for full passive RFID implementation. The DoD is requiring "passive RFID tagging at the case, pallet, and unit packaging level for all new solicitations issued after October 1, 2004, for delivery of material on or after January 1, 2005" (Wynne, 2004). In addition, the DoD is committed to establishing an initial capability to read passive tags at key sites by January 2005, and the Defense Logistics Agency will have strategic centers at San Joaquin, California, and Susquchanna, Pennsylvania, capable of reading passive RFID attached to shipments made after that date. Table 2 outlines the requirements for 2005, 2006, and 2007. While suppliers are busy meeting this requirement, DoD is establishing the logistics information systems architecture to fully integrate passive RFID information throughout the supply

chain (Wynne, 2004). DoD is a accomplishing this goal by partnering with commercial industry, such as EPC Global, and Wal-Mart (Stewart, 2004). The technical specifications of the requirement are outlined in Table 2.

Table 2: RFID Tagging Requirements by Package Level

RFID Layer	Description	Tag Type	Frequency	Read Range	Requirement
0	Item	Passive	UHF	3 m	Not yet required
1	Item Package	Passive	UHF	3 m	Some items by Jan 2005
2	Case	Passive	UHF	3 m	All items by Jan 2005
3	Unit Load, Pallet	Passive	UHF	3 m	All items by Jan 2005

(Wynne, 2004)

The DoD has completed several pilot tests. The Army, in coordination with DLA, tested RFID with individual protective equipment. The Air Force used passive RFID tag military shipping labels on select items. The Marine Corps used passive and active RFID for material visibility, and the Navy used a Smart Stores Test Facility to test RFID capability. The DoD concluded, "RFID holds significant potential for the supply chain today. We will not wait for the 5 cent tag to get started!" (Stewart, 2004).

Management of Information System Implementations

To propose a management strategy for implementation of passive RFID, as directed by the DoD, relevant literature was reviewed. First, reasons large scale information technology implementation projects fail will be reviewed. Then, the framework utilized for implementation of GeoBase will be discussed. Finally, a recent case study of the GeoBase implementation will be analyzed to determine the success of the model.

Information Resource Management Construct.

Both GeoBase and RFID systems fall under the larger umbrella of an Information Resource Management Systems. Understanding the information resource management (IRM) construct is critical to developing a strategy for a large scale information technology implementation. Although not a very comprehensive definition, the Office of Management and Budget (OMB) defined IRM in 1985 as:

> “The term “information resources management” means the planning, budgeting, organizing, directing, training, and control associated with government information. The term encompasses both information itself and the related resources, such as personnel, equipment, funds, and technology (Owen, 1989, p20).

Although this definition is a good start, a more comprehensive definition would be appropriate for this research. Lewis, Snyder, and Rainer (1995) conducted a large-scale meta-analysis of the information resource management (IRM) construct and concluded that IRM must be considered a multi-dimensional construct and proposed the following construct definition:

> “IRM is a comprehensive approach to planning, organizing, budgeting, directing, monitoring and controlling the people, funding, technologies and activities associated with acquiring , storing, processing and distribution data to meet a business need for the benefit of the entire enterprise” (Lewis, Snyder, & Rainer, 1995, p204).

Reasons IT implementations Fail.

Lieutenant General Zettler, previous Director, Air Force Installation and Logistics (AF/IL) once stated, “when it comes to management and fielding of new IT capabilities,

‘we do extremely poorly’” (Fonnesbeck, 2003, p3). Wilson (1991) outlined barriers to information system implementations, to include: measuring benefits, political conflicts, existing information technology structure, training, doubts about the benefits, telecommunication issues, management attitudes, and technology lagging behind organization needs. Over ten years later, these implementation issues don’t seem to have changed much. With a background as an IT management consultant in Europe, Smith (2004) outlined reasons why IT projects become troubled, to include:

- Poorly specified objectives that don’t focus on key business needs;
- Insufficient project management;
- Inadequate training;
- Lack of risk management.
- Poor cost estimating.
- Lack of senior leadership or management;
- Failure to divide large projects into manageable parts.

As the list above by Smith (2004) indicates, many of the barriers to successful implementation are people-barriers. Rizzuto (2003) performed a meta-analysis of the information technology literature attempting to address people factors that contribute to IT implementation failure. After thoroughly analyzing 46 multi-dimensional articles ranging from business management, organizational behavior, information science, psychology, and engineering, she concluded that system non-use, management of system planning, implementation, and maintenance as the largest contributors to implementation failure. Lack of organizational preparation was the primary reason for the poor management (Rizzuto, 2003). McAfee (2003) proposed five common pitfalls that are symptomatic of implementation failure. First, inertia is lack of progress over time. Second, misspecification is when the technology will technically work, but it does not solve the problem for which it was designed. Third, resistance seems to occur when

employees disagree on how to proceed with the implementation. Finally, misuse or non-use occurs with incomplete or incorrect implementation of the IT system (McAfee, 2003). A summary of barriers to successful implementation of information systems is included as Table 3.

Table 3: Summary of Barriers to Successful IT Implementation

Wilson (1991)	**Rizzuto (2003)**	**McAfee (2003)**	**Smith (2004)**
Measurement barriers	System non-use	Non-use/Misuse	
Political conflicts	Lack of organizational prep	Resistance	
Proper management plan			Failure to break into parts
Existing IT structure			
User education			Training
Telecom issues			
Management attitudes	Management of implementation		Management support
Technology lagging needs		Mis-specification of technology	Poor objectives
	Maintenance	Lack of progress over time	
			Poor costing

Many of the issues depicted above seem to fall under the three broad categories of individual, managerial, and organizational level issues, in line with Oliver's (2004) assessment of barriers to successful IT implementation. Although many of these causes seem obvious to the casual reader, preventing them is not so easy. To develop a successful management implementation plan for passive RFID in the DoD, it would be prudent to begin with a model of a moderately successful large scale IT implementation in the U.S. Air Force. Implementation of GeoBase—a large scale information technology project--was considered successful by most measures. In addition, analyzing

GeoBase has the added advantage that its implementation was carefully crafted, strategic in nature, and subsequently thoroughly tested.

GeoBase: Analysis of a DoD Implementation Model.

In working toward an effective implementation strategy for passive RFID, this research sought examples of successful large scale DoD IT implementations. One such example is GeoBase. GeoBase, a system developed by Colonel Brian Cullis, is an Air Force Geographical Information System (GIS) program designed to transform how personnel deal with information and IT at installations worldwide (Fonnesbeck, 2003). A GIS is an "automated system for capture, storage, retrieval, analysis, and display of spatial data" (Clarke, 2001). Analysis of the Air Force's GeoBase implementation is appropriate because it is similar, although notably smaller, in scope to implementation of a DOD passive RFID system. GeoBase is designed to eliminate problems in data standardization, data maintenance, and data accuracy across the Air Force by creating a common installation picture (Fonnesbeck, 2003). With the goal of developing, maintaining, and sustaining one geospatial information structure capable of addressing installation requirements, it should be able to significantly improve Air Force business process and decision making (Fonnesbeck, 2003). Cullis (1995) proposed a model for information technology innovation adoption for the GeoBase system, called the GeoBase Sustainment Model (GSM). This model was designed to tackle common IT implementation issues and integrate IRM best practices, see Figure 2.

The model is focused around six information resource management principles, called pillars. Although Cullis (2003) defines the pillars specifically in terms of GeoBase, the pillars are easily adapted to any large scale IT implementation strategy. The "Policy and

Guidance" pillar refers to the necessary policies and procedures to establish and maintain a large scale system. The "Financial Management" pillar addresses the financial issues required for acquisition and maintenance of the system. "People and Workflow" describes how employees will manage and coordinate system activities (Cullis, 2003). "Education and Training" refers to the required knowledge to properly implement, operate, and sustain the system (Cullis, 2003). The "Systems Architecture" pillar refers to developing standards for acquiring, deploying, and maintaining a common IT capability across the organization (Cullis, 2003). The final pillar, "Information Architecture", refers to the standards for data and applications that will available with the system.

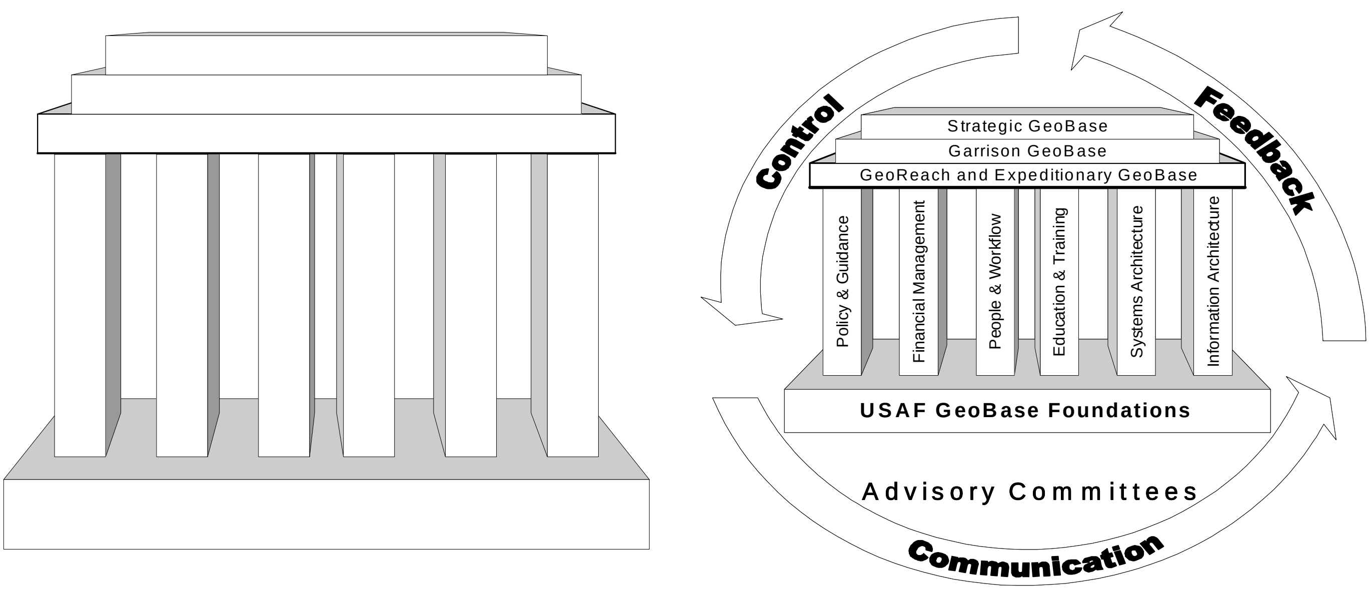


Figure 2. ***Left:*** **GeoBase Sustainment Model** ***(adapted from Cullis, 2003c)***
Right: **Oliver's (2004) Revised Model**

Over the six pillars are the four levels of structure that GeoBase will operate, to include Garrison (operations at an installation level), GeoReach (information on potential

Strategic GeoBase
Garrison GeoBase
GeoReach and Expeditionary GeoBase

forward operation locations), Expeditionary GeoBase (deployable version of GeoBase), and Strategic (senior staff access to visualize the broader picture) (Cullis, 2003). The GeoBase levels are inherently applicable to a passive RFID infrastructure requirement. Passive RFID will need to work at local base level, at major commands and higher headquarters levels, and at deployed locations.

Evaluation of the Model

Oliver (2004) and Fonnesback (2003) studied the GSM Model. Fonnesbeck (2003) utilized simulation models of the GeoBase initiative in the Air Force to test organizational information technology implementation systems. Overall, Fonnesbeck's (2003) research validated the model. Oliver (2004) tested the GSM by conducting a case study investigation of GeoBase implementation issues as perceived by USAF major command level users. In an attempt to assess the validity of the GSM model, Oliver (2004) conducted content analysis on the GSM model and the IRM concepts proposed above by Lewis, Snyder, and Ranier (1995). He concluded that the GSM concepts matched the information resource management implementation issues, but recommended several additions to the model. He concluded that communication, control, and feedback issues should be added to the model (Oliver, 2004). The adjusted model is also detailed in Figure 2 above.

Summary

Information resource management literature, specifically large scale implementations of information technology are important considerations for establishing an implementation plan for DoD RFID. The difficulties that doom information technology implementations have been carefully studied (McAfee, 2003; Rizzuto, 2003; Smith,

2004; Wilson, 1991). Past IT implementation problems seem to fall under the broad categories of individual, managerial, and organizational level issues (Oliver, 2004). The pillars identified in the GeoBase sustainment model proposed by Cullis (2003), revised by Oliver (2003), and validated by Fonnesbeck (2003) serve as a reasonable template to evaluate lessons learned to date in the DoD and Wal-Marts implementation of RFID systems. After evaluating the progress made to date, a strategic implementation plan of passive RFID in the DoD will be proposed.

III. Methodology

Overview

This chapter describes the methodology used to conduct this research and arrive at an answer to the research problem. This chapter will demonstrate the path through the investigative questions to the answer to the research question. It will then provide the method and justification for answering each of the investigative questions. Finally, it will address steps taken to ensure both the reliability and validity of this research.

Research Structure

This research is entirely qualitative. Leedy and Ormrod (2001) outline four possible purposes for qualitative research: description, interpretation, verification, and evaluation. The first two, description and interpretation, are of particular interest in this research. First, this research describes active RFID technology and its application so far, especially in the DoD. It then describes passive RFID, how it represents the next evolution in information technology, and its potential application.

Having fully described active and passive RFID, this research then describes the history of active RFID use with a focus on lessons learned. It also outlines passive RFID characteristics and applications in terms of information technology implementation. Once the historical descriptions and their associated lessons learned have been synthesized with the state of the technology and pertinent management constructs, this research will then arrive at what management approach will provide the greatest opportunity for success in passive RFID implementation.

This research applies two methodologies in its description and interpretation. The most direct will be to simply pull relevant descriptions from the literature review. The most involved will be a modified case study aimed at interpreting active RFID experience and the current course of passive RFID progress. A case study involves the in-depth study of a particular program for a specified time period (Leedy and Ormrod, 2001). This research examines active RFID experience, especially as applied in the DoD. This case study will be highly focused as the objective is not to fully describe and interpret active RFID experience, but rather to cull the pertinent lessons learned so that the DoD may take advantage of what was done right and avoid repeating the pitfalls in the implementation of passive RFID.

This case study makes extensive use of relevant literature, but also rests heavily on unstructured interviews with subject matter experts. Each interviewee was carefully chosen based on his/her familiarity and involvement with RFID implementation and analysis. Interviews were unstructured to allow the interviewees the latitude to express what they thought were the key elements of RFID experience and planning efforts. This led to avenues of analysis not originally considered, yet crucial in providing adequate data for the analysis.

The amount of case study and literature review varies from investigative question to investigative question, but generally flows from pure case study for investigative question one to pure literature review for investigative question six. One primary driver of this flow was the relative age of the technologies assessed. Active RFID has been employed in the field for a number of years and, therefore, enough data exists to perform a case study adequate to support the analysis. Use of active RFID can be fully assessed

and lessons learned are readily available. Furthermore, there are personnel who have actual experience with the operational system and can provide accurate accounts of that experience. Conversely, passive RFID has yet to be fully employed in the field so data only exists in the form of technical specifications, working group plans, and conjectures of how the system should look once fielded.

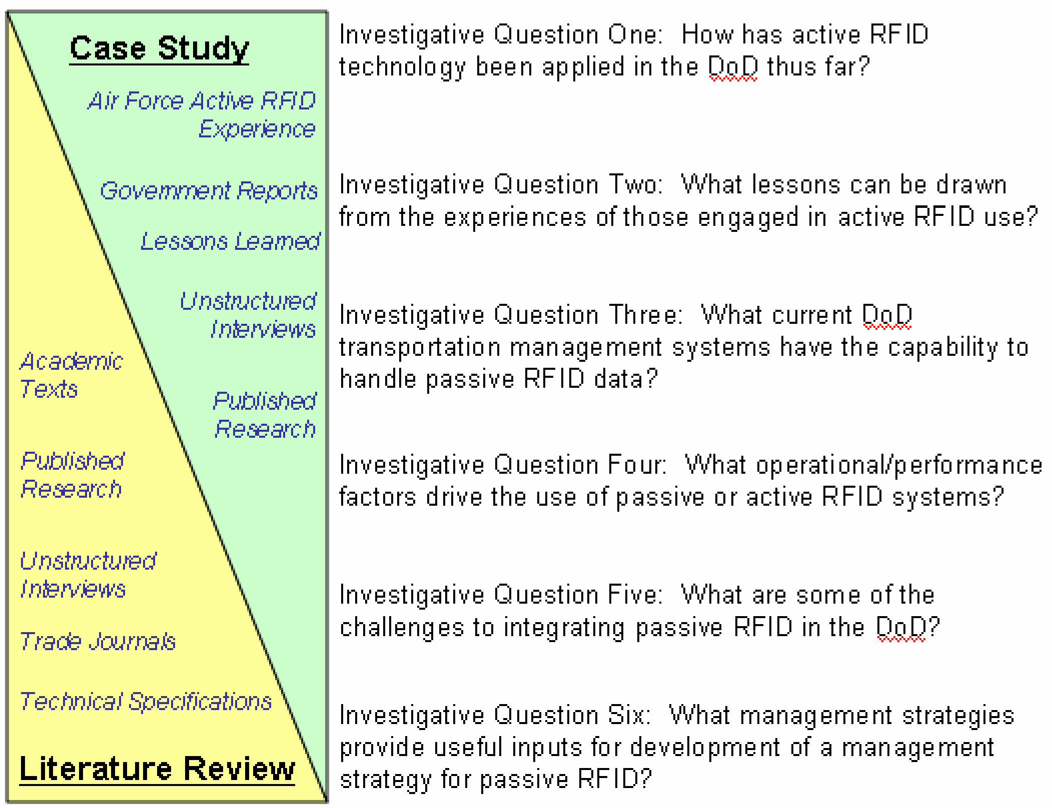


Figure 3: Methodology Overview

Investigative question one is answered purely through the case study. Data is gathered from government reports and published academic research assessing RFID use, and unstructured interviews with program office, using command, and civilian experts. This case study will provide the historical background for RFID use to date.

Investigative question two is answered primarily through the case study. This research question differs from research question one in that research question is a simple reporting of RFID experience. This research question focuses on assessing that experience and developing and reporting lessons learned. Some literature provides published lessons learned from various RFID applications which support this research.

Investigative question three is answered by both the case study and the literature review. In addition to the data gathered to answer numbers one and two via the case study, published material identifies DoD information technology systems and capabilities. Unstructured interviews with appropriate subject matter experts were used to fill gaps in the literature and case study.

While much of the data answering investigative question four comes from the case study, the balance here shifts in favor of the literature review. Published technical specifications provide passive RFID capabilities. Unstructured interviews with DoD and commercial experts, along with current published journal articles provide the bulk of data required to assess where each technology fits.

Investigative question five is answered primarily through interviews with subject matter experts. The literature review provides some generic IT implementation issues which will also be addressed in the analysis. The case study shows the current view of the requirement for information at various levels of management.

Investigative question six is addressed almost exclusively through the literature review. Academic texts and published research provide extensive data on what constitutes successful management of IT implementation. Academic texts provide general management constructs and RFID IT providers have published RFID

implementation checklists. Published research provides real-world instances of IT implementation success or failure for other IT implementations with similarities to passive RFID.

Once Active RFID history and lessons learned are fully explored and understood, combined with the capabilities and management requirements for passive RFID and available DoD information architecture, they are then married with IT implementation theory. This marriage begets an appropriate management strategy for passive RFID acquisition and implementation.

Reliability and Validity

Interrater reliability involves having two or more raters examine the same data (Leedy and Ormrod, 2001). Given that this research was conducted by two individuals with different backgrounds, each of whom separately reviewed and analyzed every piece of data, the reliability of this research is significantly enhanced.

Leedy and Ormrod (2001) also provide additional strategies for ensuring validity in qualitative research, including triangulation, thick description, feedback and respondent validation. By asking the same questions of multiple interviewees and collecting multiple sources for all aspects of the literature review, precise answers for most of the investigative questions were effectively triangulated. The literature review was "thick" enough to provide adequate detail such that other researchers could draw their own conclusions from the data. In addition to the research advisor, this effort employed a reader with extensive background in information technology implementation, whose feedback enhanced the validity of this analysis and conclusions. Finally,

interviewees were employed to review written documentation of the interviews as well as the analysis and conclusions, again enhancing the validity of this research.

Conclusion

This chapter outlined the methodology for this research. It described the research as qualitative, employing both extensive literature review and a modified case study to answer the investigative question and ultimately resolve the research question. The chapter provided the rationale for this methodology and its linkage to the data. It demonstrated how the two methodologies ultimately blend together to arrive at an effective management construct for passive RFID implementation. Finally, it addressed the enhancement of both the reliability and validity of the research.

IV. Results and Analysis

Chapter Overview

This chapter will provide the analysis and results of this research project. The chapter will answer each of the investigative questions utilizing data gathered during the literature review and through unstructured interviews. Subsequently, this chapter will answer the research question, how to apply active RFID experience toward an appropriate management strategy for passive RFID implementation.

Interview Background

Interviewees were selected based on their specific knowledge of the subject area at hand. Key interviewees were selected from various major command and DoD-level positions where they had specific knowledge of DoD's active RFID implementation and/or were actively engaged in DoD's or Wal-Mart's efforts to establish a passive RFID program. Although the transcripts from interviews are included in Appendix A, names are kept confidential by request.

Investigative Question One

How has active RFID technology been applied in the DoD thus far?

With the desire not to repeat the logistics disasters of the first Gulf War, the DoD was committed to be early adopters of RFID technology. As described in Chapter 2, RFID has the potential to provide the DoD supply chain tremendous benefits in inventory management, in-transit asset visibility, and interoperability by eliminating much of the uncertainty in the supply chain (Stewart, 2004). By streamlining business processes and partnering with industry, DoD will be able to reallocate critical manpower resources to various war-fighting functions (Wynne, 2004).

Active RFID was the first technology out of the gate and ready for implementation. Accordingly, a study of the DoD's experience with active RFID is essential to arriving at an implementation strategy for passive RFID. Answered through the case study data gathered from government reports, published academic research assessing RFID use, and unstructured interviews with program office, using command, and civilian experts, Investigative Question One provides the background on active RFID applications in the DoD.

DoD Utilization of Active RFID.

To date, the DoD has primarily used active RFID for in transit visibility (ITV) applications on major end items and cargo movements within the Defense Transportation System (DTS). Active RFID is used by all the Services, Agencies, and Combatant and Supporting Commands to facilitate the goal of ITV for logistics (Joint Logistics Board, 2004). In early 2003, General Tommy Franks ordered active RFID tags be placed on all air pallets, containers, and commercial sustainment shipments supporting the War on Terror (Caterinicchia, 2003). In October 2003, the Acting Undersecretary of Defense for Acquisition, Technology, and Logistics, Mr. Michael W. Wynne, formalized this directive by establishing an initial policy requiring active RFID use in the DoD (Wynne, 2003). Now in final form, the Radio Frequency Identification (RFID) Policy clearly outlines both the active RFID requirements and the initial implementation plan for future adoption of passive RFID. The policy requires all DoD components to utilize high data capacity active RFID in the DoD operational environment. All consolidated shipments moving to, from, or between overseas locations must be active RFID tagged with content level detail in order to facilitate in transit visibility. Content level detail includes data that

describes the asset and minimally identifies each level of a complete shipment entity (Wynne, 2004).

The active RFID business rules require data-rich, active RFID tags to be placed on Layer 4 freight containers and palletized shipments when departing for overseas locations. Layer 4 freight containers include 20 and 40 foot sea vans and large engine containers, while palletized cargo refers to 463L air pallets of DoD cargo. Specifically, the policy requires active RFID tags on the following when departing for overseas locations:

- *Sustainment/Retrograde Cargo*
- *Unit Movement Equipment and Cargo:* Only self deploying aircraft and ships are exempted.
- *Ammunition Shipments*
- *Prepositioned War Reserve Material and Supplies* (Wynne, 2004).

United States Transportation Command (USTRANSCOM) established seven Air Mobility Command (AMC) air terminals to establish and process the active RFID tags. In total, over 45,000 active tags have been burned (written) in support of Operation Iraqi Freedom and military cargo movements to South America, Europe, and South Korea. These tags have been placed on sustainment cargo built on 463L pallets.

In addition to DoD directed active RFID requirements in support of the War on Terror, individual units have pursued specialized uses of active RFID for reasons other than supply chain management or in-transit visibility. For example, a base in New Mexico, utilizes an active RFID technology to track aerospace ground equipment on their flight line. This technology utilizes triangulation of active RFID signals to locate each piece of ground equipment along several miles of flight line (CDO Technologies, 2004). Although this technology is valuable for its designated purpose, it has been utilized on a

limited basis and does not offer “lessons learned” for development of a passive RFID strategy.

Active RFID Performance.

Although the DoD’s use of active RFID has significantly improved asset visibility en route to the theater for OIF, the Government Accounting Office and others (3ID[M] AAR, 2003; JLL, 2004; USA OIF SG, 2003; O’Brien, 2004) have outlined ITV problems that still exist. First, RFID was not utilized to track all material, as directed. Second, logistics systems were not fully interoperable. Data that was visible in one system was not necessarily visible in another system (O’Brien, 2004). Third, receipts of goods were not closed out properly causing ITV to suffer (GAO, 2003). Finally, long, fast-moving, and dynamic supply lines limited asset visibility within the theater. The visibility broke down between port and foxhole (O’Brien, 2004). Overall, the insufficient and improper use of active RFID for tracking containers resulted in a $1.2 billion dollar shortfall between what was reportedly sent to Iraq and what was received (McLaughlin, 2004). Clearly progress with active and passive RFID still needs to be made to solve the DoD’s logistical issues.

Summary

Investigative Question One described the utilization of active RFID to date and outlined RFID shortcomings noted during OIF. Investigative Question Two will specifically discuss the lessons learned from the DoD’s RFID experience that can be applied to the development of an implementation strategy for passive RFID.

Investigative Question 2

What lessons can be drawn from the experiences of those engaged in active RFID use?

The broad scope and potential applications for RFID use are offset by the relative age and immaturity of the technology. The limited use of RFID to date, either in the DoD or the private sector, results in a lack of experience from which lessons can be drawn. While the body of experience is not great, the application discussed in question, along with the similarly limited experience of the private sector, provides adequate data to support this research. Both positive and negative lessons are available which will substantially add to this analysis and support its conclusions.

Logistics System Support Issues

One thing DoD experience so far has made quite obvious, is that RFID, or any logistics information system, can not succeed without adequate infrastructure. Operations in Afghanistan and Iraq have revealed a number of inadequacies in infrastructure that prevented the full realization of active RFID benefits (Chisholm, 2004).

Communications bandwidth was a key shortfall across the spectrum of logistics operations in Operation Iraqi Freedom. Following operations in Afghanistan, the DoD's after action report acknowledged that military leaders did not have the required asset visibility because communications support required to transmit data from multiple collection points was inadequate. This lack of adequate communication support reappeared in Operation Iraqi Freedom (GAO, 2003). Clearly, all the data collection capability in the world is useless unless it can be collated into useful information and put into the hands of the decision makers who need it.

Another constraint preventing full exploitation of active RFID effectiveness in OIF was the lack of theater transportation. Distribution of supplies to forward areas was frequently delayed due to a lack of available transportation assets (GAO, 2003). When properly implemented, RFID, or any enhancement in ITV, should reduce the necessary amount of assets in the supply chain, thus reducing the required amount of transportation assets. But however good the information and how effective the reduction of necessary assets, large quantities of war materiel will still need to be moved in theater, meaning adequate transportation will always be crucial. Without adequate transportation, even the most effective RFID investment and implementation will only amount to a costly sub-optimization that yields no improvement in the overall system.

Training and Application Issues

Operation Iraqi Freedom revealed a number of failures to properly apply active RFID technology. Active RFID tags were not used uniformly and consistently (GAO, 2003). When this new technology is applied inconsistently, it has little hope of achieving its stated goals. If a commander requires all portions of his war fighting capability to be in place before commencing operations, but only has visibility for part of that capability, he still can not plan effectively. In some cases, partial system application may be no better than no application at all.

Another problem noted in OIF was that active RFID tags often carried incomplete information (Chisholm, 2004). It seems that an RFID system is subject to the same "garbage in, garbage out" vulnerabilities that may befall any information system. In some cases, tag information was lacking all the data necessary to fully describe the

contents of the pallet or container it was attached to. In other cases, tag information failed to carry the right transportation data. In either case, critical ITV was lost.

Perhaps the most fundamental, and most surprising, failure mode comes from the fact that active RFID readers were often left in the "off" position during operations (AFMC, 2004). After going to all the trouble to transport RFID equipment into theater, carry it to its operating location, and set it up, troops simply forgot to turn it on. Again, no matter how good the technology, even the simplest of human errors can render it fruitless.

All the above issues can be traced to the newness of RFID in the field and the fact that front line troops were unfamiliar with the equipment. Many forward locations had never even heard of RFID prior to commencing operations (Chisholm, 2004). The most basic lesson learned from active RFID experience mirrors lessons learned from countless other enterprises and operations: without adequate training, the best that can be hoped for is little or no gain, the worst is abject failure. Here, the DoD failed to achieve the desired gain by using active RFID in forward areas as ITV broke down in theater.

Paradigm Issues

New technology implementations frequently need to be accompanied by paradigm shifts that enable the full exploitation of the technology. One such paradigm shift required to fully exploit RFID technology would run concurrently with a paradigm shift taking place in the private sector: the shift from stovepipe organizations in adversarial relations toward partnerships encompassing the entire supply chain. One of the biggest lessons to be taken from active RFID is the need to look at the "end-to-end" supply chain (USTRANSCOM, 2004). In the case of OIF, this certainly refers to the

downstream infrastructure failures mentioned above. If the "tip of the spear" is not ready to receive, then all proceeding effort may be wasted.

Limited private sector experience with bringing passive RFID in the supply chain also provides a case in point. The Wal-Mart mandate includes a requirement that the RFID tag contain information that can only be added late in the production process. This lack of flexibility will add costs to the manufacturers who supply Wal-Mart (Collins, 2004). As the retail industry's "800lb gorilla," Wal-Mart has the near-monopsonistic purchasing power to demand their suppliers bear this additional cost, this one-sided negotiation fails to maximize profit for the entire supply chain. The irony here is that Wal-Mart, long recognized as forward thinking innovators of supply chain management has reverted to the old, adversarial business practices (Collins, 2003; DoD AIT, 2004) . There is no evidence that the DoD has the power or desire to mandate its supplier bear the cost of RFID implementation without passing them on, nor would they necessarily want to. As such, DoD would be wise to consider the upstream elements of the supply chain as well as downstream.

While what can and can not be expected from suppliers in terms of cost is still to be defined, what can be expected in terms of tagging is not. Here again, reference a failure mode from OIF: many items that should have been tagged by vendors in fact showed up without tags (Chisholm, 2004). While outside the DoD, these vendors represent the early stages in the supply chain, and their effective participation is a necessary element of our implementation success. The new paradigm of supply chain management demands partnership with vendors to ensure both effective and efficient supply chain business practices for passive RFID implementation.

Another paradigm shift necessary for effective passive RFID implementation is that same one DoD has been working on in general for decades: the transition from stovepipe military services to fully joint operations. Nowhere is the need for progress in this area more evident than in the logistics arena. Multiple services worked together at forward location supply activities throughout OIF. However, different acronyms, mismatched cultures, incompatible communications, multiple stock numbers for similar items, and service-unique processes led to challenges which have yet to be overcome (Wood, 2004). As the individual services develop their own CONOPS for passive RFID, great care must be taken to ensure adequate commonality between services to ensure interoperability while providing the flexibility required to meet service-unique requirements.

One study of active RFID use is very illuminating. RFID tagged and non RFID tagged containers were studied to see if there was a significant difference in how long it took them to pass through aerial ports of embarkation. The study concluded that the RFID tagged containers were actually processed more slowly through the ports, and that this may be due to the fact that it was an Air Force port and the RFID tagged containers were Army containers with which the Air Force personnel were less familiar (Method, 1999). This inter service confusion provides one reasonable explanation. Another may be related to the training issues listed above. Personnel may simply have handled the cargo they knew how to handle first and saved the new RFID tagged cargo for last. Either way the lesson learned is that the services must learn to talk to each other, including training with each other’s equipment where appropriate.

These inter service difficulties are also indicative of a larger, systemic problem in the DoD; the lack of a single DoD-level leader responsible for all logistics functions. Since passive RFID is supposed to facilitate joint total asset visibility and interoperability through the range of joint operations in the field, the current practice of each service developing a unique CONOPS could lead to a very dis-integrated system rather than a fully integrated system. USTRANSCOM is designated as the using command for RFID. However, their concern is only with ITV, and especially strategic ITV. Once a pallet is unloaded at a point of debarkation and its items distributed among various short-haul modes in theater, USTRANSCOM's role diminishes greatly, if not altogether. For passive RFID to fully deliver on its promise, it should be under the auspices of a single DoD-wide end-to-end supply chain manager, which does not currently exist.

Positive Experiences

It's always easier to spot what went wrong than what went right. Active RFID experience was not without its successes, however. One key to the limited success that Active RFID enjoyed in OIF was the critical decision of where and how to route the information collected via active RFID tags through the myriad of DoD logistics information systems. The DoD currently maintains over 7,000 logistics information systems of various sizes, functionalities, and levels of interconnectivity (AFMC, 2004). The most obvious choice would have been to rout updates from RFID tag reads into the Global Transportation Network (GTN) via the Cargo Movement Operations System (CMOS). GTN is the official centerpiece of all DoD IT efforts and CMOS is a natural conduit. However CMOS is only updated once every 12 hours and GTN can be cumbersome to use, especially for front-line operations. Instead, RFID tag reads were

routed directly into the Defense Automated Address System (DAAS). DAAS is updated continually and is easier to access and extract necessary information (AFMC, 2004). The closer you get to the front line, the more critical the element of time becomes. For forward-deployed decision makers, an up to 12 hour delay in ITV would not provide information timely enough to make decisions in modern warfare. Therefore, the decision to use DAAS was clearly superior, if not quite as apparent.

One anecdote that demonstrates the benefits of RFID-enhanced ITV actually comes from coalition forces in OIF. A British forward unit had an urgent need for a new tank tread, which had been ordered, but had not yet arrived. With rapid, easy access to their ITV system, the unit was able to quickly locate their tread, which was nearby and would arrive soon. Were they not able to do so, they would have ordered another tread at a cost of $3 million. Given that the British had invested $5 million in their entire RFID system, they saved over half of it with this one cost avoidance (Chisholm, 2004). This is exactly the same type of scenario the DoD hopes to capitalize on with RFID. This was undoubtedly easier for the British as they were moving far less materiel in theater than the US. However, DoD must recognize what is at stake to achieve similar results.

Summary

Investigative question two builds on investigative question one by taking past active RFID experience and gleaning lessons learned which will provide key inputs to an implementation strategy for passive RFID. These lessons learned included: 1. the requirement for a system-level perspective including adequate infrastructure, transportation assets, and avoidance of sub-optimization, 2. proper application of the technology including the necessity of adequate training, 3. necessary paradigm shifts,

including movements toward effective joint operations and supply chain management, and 4. the positives of selecting the right information system conduit and the dramatic benefits of a single ITV success. Investigative question three will focus on a system level perspective with regards to the information technology infrastructure as it looks at DoD logistics information systems.

Investigative Question 3

What current DoD transportation management systems have the capacity to handle passive RFID data?

DoD logistics is a huge enterprise encompassing billions of dollars in expenditures per year, hundreds of activities spread throughout the world, and thousands of processes employed to provide the war fighter with time and place utility. The number and variety of information systems currently in use supporting DoD logistics is equally staggering. As noted in the analysis for the previous investigative question, there are over 7,000 logistics information systems employed by the DoD (AFMC, 2004). Which, if any, of these systems have the capacity and functionality to ensure the data captured from passive RFID transactions is converted into useful information and made available to the decision makers who need it? This investigative question will look at the current and emerging DoD logistics information systems architecture and narrow those down to systems which may be useful for passive RFID implementation. It will also provide some discussion of the current and ideal state of DoD logistics information systems.

Overall System Architecture

Getting a grip on the myriad of logistics information systems serving the DoD is a daunting task. No matter how daunting, though, getting an overall picture of the DoD's logistics effort is absolutely essential to effective and efficient war fighting operations. Toward that end, the Army developed the Logistics Common Operating Picture (LCOP). The LCOP integrated three main systems and their subsystems: the Joint Deployment and Logistics Model (JDLM), which provides graphic displays, modeling, and data mining, the Integrated Logistics Analysis Program (ILAP), a data repository, and the in-transit visibility (ITV) network, which provides movement tracking. GTN was useful at the strategic level, but the Army wanted to track assets at the operational and tactical levels, which drove the construction of an ITV network as one of the pillars of the LCOP. The Army believes that a strength of the LCOP lies in its fusion of existing capabilities to provide the war fighter a complete tactical picture (Caterinicchia, 2003).

Similarly, the Air Force has contracted Intergraph to develop a Supply Chain Common Operating Picture (SCCOP). This HQ USAF/IL initiative will begin with the forecasting, purchasing, manufacturing, and distribution of a part, and continue through its delivery and eventual arrival at a source of repair. The focus here is to ensure quick, reliable, accurate information delivery to whatever activity needs the information (Frost, 2004).

While LCOP and SCCOP represent the DoD's most recent efforts at logistics information integration, most logisticians are more familiar with a somewhat older attempt at logistics information systems integration, the Global Transportation Network (GTN). Begun in the early 1990s, GTN was intended to provide comprehensive in-

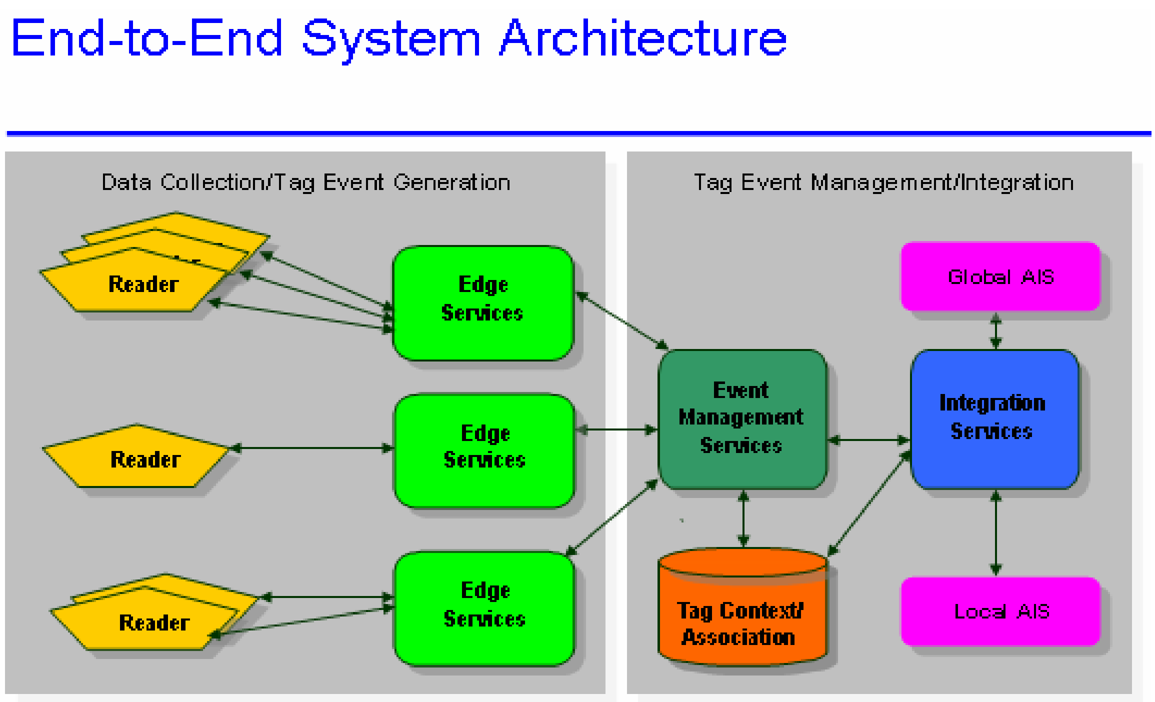
transit visibility throughout the DoD. GTN is at the very core of the ITV network mentioned above in the LCOP, and RFID is expected to be the technology that finally brings the GTN vision to fruition. Given the DoD’s current and emerging logistics information infrastructure, GTN will be the natural repository for RFID generated information. Indeed, the business rules for passive RFID require that RFID generated information be fed into ITV servers that are GTN compatible (Wynne, 2004).

The diagram below shows the end-to-end system architecture for RFID. The diagram shows the data collection and tag event generation phase beginning with RFID readers and proceeding through edge services. Edge services, as used in this description, consist of the collection of nodal data and the creation of tag events. The RFID generated data will then proceed to the tag event management/integration phase, first to event management services which will then seek the appropriate tag context/association and feed the information into integration services, which will finally make the information available to local automated information systems.

Specific Systems Discussion

The key question here is which information systems should provide the event management services. The CONOPS for USAF passive RFID military shipping label initial capability states that initial RFID edge services will interface with the Cargo Movement Operations System (CMOS), Depot Supply System (DSS), Global Air Transportation Execution System (GATES), the Defense Automated Addressing System (DAAS), and the Radio Frequency In-Transit Visibility (RF-ITV) server (Northrop Grumman, 2004).

Figure 4: RFID End to End System Architecture

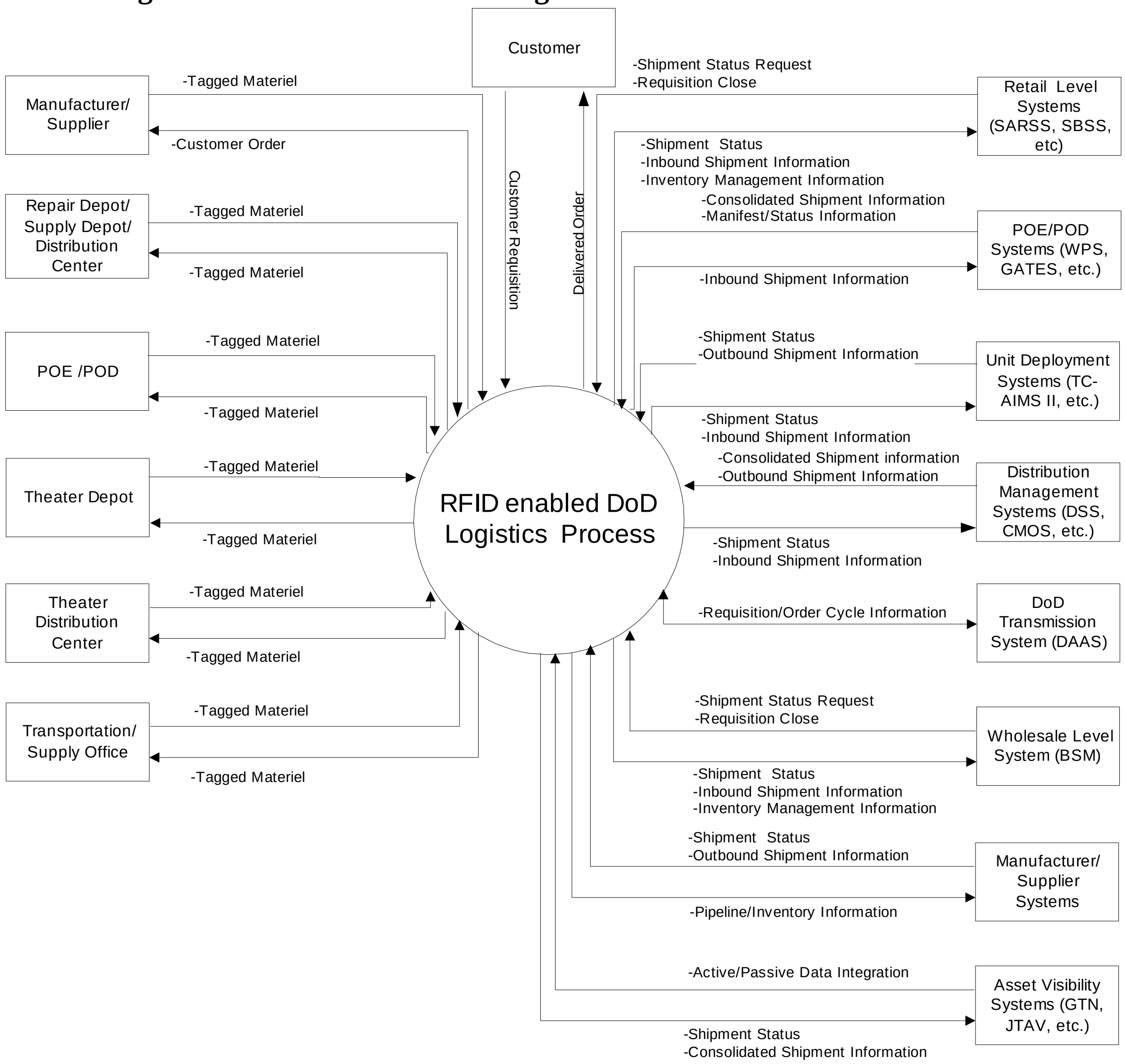


(DoD RFID Data Collection Infrastructure, 2004)

In addition, the potential exists to tie in RFID data to other ITV systems including the Government Freight Management (GFM) system, the World Wide Port System (WPS), the Standard Army Retail Supply System (SARSS), the Surface Transportation Management System (SMTS), the Movement Tracking System (MTS), and the Transportation Coordinators' Automated Information Movement System (TC-AIMS II) (Carpenter, 2004).

Figure 5 shows which logistical processes could be performed with a number of existing systems using RFID generated data.

Figure 5: RFID Enabled DoD Logsitics Processes



(OSD SCI, 2004)

Discussion of Findings

The current vision for passive RFID has the new data flowing through at least five of the 7,000+ logistics information systems available to the DoD. Many envision RFID eventually feeding dozens of systems. However, the question remains as to which will provide the primary conduit for RFID data. While the CONOPS specifies a requirement

for RFID data to be compatible with five systems, the current vision dictates CMOS as the primary link between the RFID tag reads and GTN. As noted under investigative question two, one of the positive lessons learned from active RFID experience was that DAAS provided a superb link for the ITV information generated by active RFID. The time factor for system updates was a key reason for this success. While CMOS updates GTN once every twelve hours, DAAS updates GTN once per hour or when 1MB of total data has accumulated (Miller, 1996). Given that passive RFID is expected to take the ITV success DoD enjoyed from CONUS to theater and extend it that "last mile" in theater, the criticality of this timeliness is enhanced. Forward units will find information less than one hour old especially helpful in an environment where an entire engagement can be won or lost in the space of twelve hours. The GAO criticized the DoD for not learning the logistical lessons of the first gulf war before OIF (Solis, 2003). While history frequently repeats itself in the form of mistakes, here is an opportunity for history to repeat itself in a positive way by choosing the right conduit for RFID data as demonstrated by DAAS in OIF.

Whatever interfaces are ultimately chosen, DoD can be assured that system integration will represent a major effort. The literature is devoid of specific discussion as to the acquisition of middleware or other interfaces to enable the integration of RFID data into our existing systems. This crucial area has not been ignored as the OSD has estimated system integration at 47% of total program costs, which is not out of line for projects of this nature (OSD SCI, 2004). However, given the fact that other elements of passive RFID system acquisition and implementation have received thorough discussion of specific issues, the lack of substantive discussion on this topic is cause for concern,

especially as the level of effort necessary for systems integration is frequently underestimated in large scale IT programs (Smith, 2001). System integration must have the same level of attention as any other aspect of passive RFID implementation for the project to be successful.

One final system-level approach is worth considering. While the DoD currently has over 7,000 logistics information systems in use, Wal-Mart has only three, and they have plans to go down to one. Likewise, the DoD has plans to let many systems “brown out” in the near future, hundreds will still remain (AFMC, 2004). While there are many differences between Wal-Mart’s logistics operations and the DoD’s, there are also many similarities. Both are world-wide, both are focused on putting the end item in the user’s hands as quickly as possible, and both are very large, requiring tremendous throughput using multiple modes of transportation. If Wal-Mart, a world leader in efficient supply chain management, has determined they can get by with a single integrated logistics information system, the DoD should be able to cut the number of its systems far more substantially then indicated. While more costly in the near term, the elimination of hundreds or even thousands of legacy systems would spell substantial long-term, cost savings as one or a few true open architecture systems built with future requirements in mind replaced older, maintenance intensive systems that require extensive integration efforts to accommodate new functionalities. Given the tremendous investment the DoD has in many of these systems, this research acknowledges the political and fiscal reality that this type of massive change is unlikely, but that does not diminish its attractiveness. This attractiveness is greatly enhanced once the realization is made that these are sunk costs which are not recoverable and not relevant to the decision.

Summary

Investigative question three looked at the current state of DoD logistics information systems with an eye toward their ability to incorporate passive RFID generated data. DoD system level architecture was discussed along with how passive RFID would fit into this architecture. Suggestions were offered, including using DAAS as the conduit between passive RFID and GTN, paying close attention to the integration effort, and even developing a new DoD wide logistics information system that would allow the elimination of thousands of legacy systems and readily accommodate new functionalities like passive RFID. Investigative question four will focus on the unique characteristics of active and passive RFID and how those characteristics drive their potential application.

Investigative Question Four

What operational/performance factors drive the use of passive RFID, active RFID, or neither technology?

As covered in previous chapters, there are generally two categories of RFID—active and passive. The difference between the two types is not as clear as it may first appear. Most Active tags operate with a power source, usually a battery, while most passive tags don't have a battery. However, some passive tags do have a small battery to extend the range at which they can be read. As Chapter 2 sufficiently explained, the DoD has embarked on an extensive active RFID infrastructure and network, but is now working on a passive RFID structure and capability. This investigative question describes the operational and performance characteristics that drive the need for different

RFID technologies and outlines how DoD plans to integrate both into their business architecture.

Operational Considerations for Selection of Active or Passive RFID Systems.

Distance to read. The most basic operational factor driving the use of active or passive RFID systems is the distance at which the tag needs to be read. This need is driven by the tag's function. In general, passive tag ranges are up to about 20 feet (but usually reside closer to 10 feet), depending on the frequency employed by the tag system (McCall, 2004). Passive tags are only activated when a high frequency signal is bounced off them from an interrogator (or reader). Otherwise the tag does not emit any signal. On the other extreme, active tags can be read from distance of 300 feet, or more (Donnelly, 2004). This distance is achieved because the tag is constantly emitting its own signal. Therefore, the distance that you need to be able to read the tag may drive the type of tagging system utilized.

Data storage. The quantity of data stored on the two tagging systems varies considerably. Current Generation 1 (Class 0 or Class1), passive tags can store 64 or 96 bits of information (Wynne, 2004). The new Generation 2 tags that should be out within a couple of years will be able to store 256 bits of information. This increase in capability of passive tags from Generation 1 to Generation 2 is significant. Generation 1 tags only hold unit identification data, while generation 2 tags will be able to hold other pertinent supply chain information (manufacturer, etc). Active Tags have significantly more memory, holding up to 128 kilobytes of data. An active tag applied to the outside of a large container or pallet can easily handle all the content level detail for the enclosed items, along with additional logistics information.

Frequency Range. The read range is determined by the frequency utilized by the RFID system and the subsequent tagging system employed. In general, lower frequency systems utilize passive tags, while higher frequency systems utilize active tags. Frequency range is often determined by the type of material that you need the signal to penetrate. Water or other liquids can totally block 2.45 GHz signals, and no frequency range is capable of penetrating metal containers (Intermec, 1999). If the system needs to be used in, on, or around metal containers, it must be an active RFID system (AFMC, 2004). Table 4 outlines the impact of frequency on read ranges, data transfer rates, and usable applications (Microlise, 2003).

Table 4: Impact of Frequency Range on RF Tagging System

Frequency Range	LF (125KHz)	HF (13.56 MHz)	UHF (300 - 1200 MHz	Micrrowave (2.45 & 5.8 GHz)
Read Range	<0.5 meters	1 meter	100 meters (active)	10 meters (active)
Power Source	Passive only	Passive only	Generally active	Active or Passive
Typical Applications	Access control Vehicle security animal tracking	Item level tracking smart cards	Pallet tracking Toll collection	assett tracking toll collection
Data Transfer	slower	⟷		faster
Energy Absorption	less	⟷		more
Energy Efficiency	higher	⟷		lower

(Microlise, 2003)

Connectivity to a host system. Whether or not the system is connected to a larger operating system sometimes drives the type of tagging system. For passive RFID data to be useful, a host system must be accessed to provide information on the passive tagged items interrogated by the reader. Otherwise, it's just a bunch of numbers. Passive systems work by marrying up the information stored on the passive RFID tag with an Advance Shipping Notice (ASN). Once the ASN is married up with the data on the tag, the data becomes useful information. Active systems, on the other hand, have a larger

memory capacity and, therefore, carry enough information to be useful even when not connected to a host system. However, if the active system is being used for ITV, then connection to the host system will be necessary to update the system once the location changes (AFMC, 2004).

Self-initiation of Communications. Another potential driver of the type of tagging system is whether or not the tagged items need to be able to initiate the communication or whether they only need communicate when interrogated by a reader (AFMC, 2004). Active RFID systems emit a signal all the time, so they self-initiate communications, while passive RFID systems only emit a signal when interrogated. For example, a new application of active RFID systems is Real Time Location System (RTLS). These systems use triangulation of emitted signals to provide real time location of items, such as items in a shop, equipment on a flight line, or pallets in a warehouse.

Encryption/Security. Although active tags emit a signal all the time, they also have the capacity to be encrypted. This feature can significantly increase security in a wartime environment. In addition, active tags can receive a signal to be turned off, until another signal is received to begin emitting again. This feature also provides a certain level of security (AFMC, 2004).

Cost. As expected, the costs of implementing an RFID system, whether active or passive is high, but the potential payoffs are high, too. Although the cost of the tags are minor compared with the total cost of system implementation, the cost of the tag will often drive the type of tagging system utilized. The cost of an active tag is generally around 15 dollars, while the cost of a passive tag is down to about 50 cents. Although many propose that passive tags must approach the 1 to 5 cent range to become

ubiquitous, 50 cents is still considerably less than 15 dollars. Passive tags with rewrite capability will cost more than passive tags without rewrite capability, but will still be significantly less expensive than even the most basic active tag. As outlined in earlier, the DoD has been using active RFID technology at the case and pallet level for the last couple of years to support ITV requirements for the Global War on Terror. To date, the DoD has purchased over 600,000 active tags (AFMC, 2004). To tag at the item level, which is the eventual goal of passive RFID systems, the cost would be astronomical at 15 dollars per tag. Therefore, item level tagging must utilize passive RFID technology. However, while the DoD has expressed an interest in item-level tagging, this research does not assert a requirement to tag at the item level.

Summary. As demonstrated above, there are many operational and performance characteristics that must be considered when deciding whether to proceed with an active or passive RFID system. Table 5 summarizes the considerations discussed above and offers a management recommendation. However, for some applications, such as the DoD, it may be appropriate to utilize both systems. The remaining part of this investigative question discusses how the DoD plans to use active and passive systems to compliment each other.

Table 5: Operational Considerations for Active or Passive RFID Systems

	Type of RFID System		
Operational Consideration:	**Passive RFID Tags**	**Active RFID Tags**	**Recommendation:**
Read Distance	10 to 20 meters	300 meters	Use passive for short distance; active for long distances and location analysis
Data Storage Requirments	64 to 128 bytes	128 Kilobytes	High data storage capacity mandates active RFID technology
Frequency	125 KHz to 5.8 GHz	300 MHz to 5.8 GHz	Utilize federally aprovied frequencies based on particular application
Connectivity to host	Essential to apply data	Only critical for ITV	Active RFID more applicable in austere locations (no connectivity)
Self-initiated Communication	No	Yes	If you need a constant signal to be emitted, use active
Cost	Relatively low	Relatively high	If tagging at the item level, passive RFID essential

DoD Combines Active and Passive RFID Systems.

The Department of Defense Concept of Operations for RFID released in June 2004 outlines how the DoD plans to incorporate passive RFID with their considerable investment in active RFID (OSD SCI, 2004). Some ITV shortcomings, listed in previous sections, have been well documented during OIF, especially on the last tactical mile of the logistics journey from the port to the foxhole (GAO, 2003). However, there is no dispute that DoD has significantly improved their in-transit visibility of cargo moving around the globe with active RFID technology. The DoD plans to use passive RFID to compliment their current active RFID initiatives. The active RFID system is generally used to provide ITV as assets move through the Defense Transportation System (DTS). Active tags are utilized at the container and pallet level, while passive tags will be utilized at the lowest level possible—boxes, cartons, and eventually individual items. While active tags have provided excellent visibility as cargo moves through transportation nodes (such as ports); passive RFID will provide item or content level visibility (OSD SCI, 2004). Figure 6 demonstrates the interaction between active and passive RFID systems for supply chain integration in the DoD.

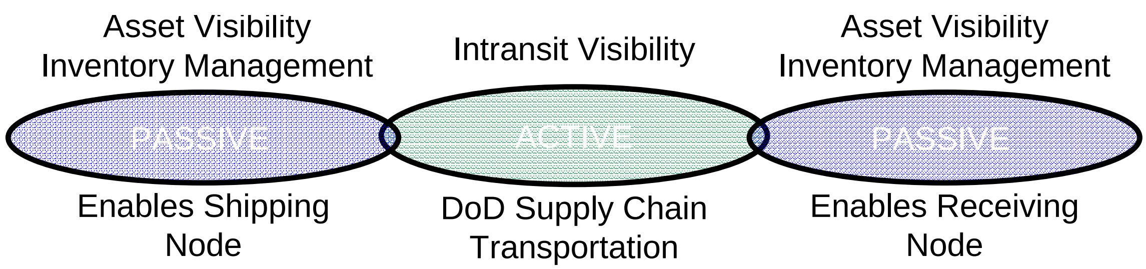


Figure 6: Integration of Active/Passive RFID (OSD SCI, 2004)

Utilizing more of a supply chain look at the integration, Figure 4 outlines the flow of goods and materials from manufacturers or suppliers to the final customer, whether at a fixed base or foxhole. In general, active RFID will be utilized for ITV on assets traveling through the DTS, while passive RFID will provide the content level detail necessary to adequately improve the DoD's supply chain processes (OSD SCI, 2004). This discussion outlines a proposed concept of operations, whether or not the technology and processes have matured enough to progress down this path will be discussed in an upcoming investigative question.

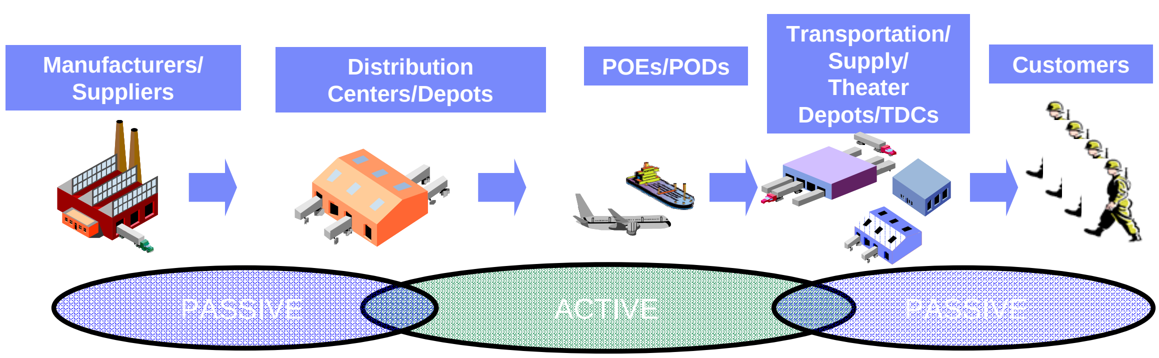


Figure 7: Proposed Supply Chain Process with an Active and Passive RFID System

(OSD SCI, 2004)

Summary

Investigative Question Four has outlined the operational and performance characteristics that may dictate whether to choose an active or passive RFID system. In addition, this section suggests that the two technologies are not mutually exclusive, and in fact, outlines how the DoD proposes to implement both processes in compliment with each other.

Investigative Question Five

What are some of the challenges to integrating passive RFID in DoD?

A complete answer to this question would be a graduate thesis by itself. For purposes of this research, Investigative Question Five will only serve as a brief outline of some of the challenges that implementation of passive RFID will need to overcome. This section will *not* attempt to discuss each of the challenges in depth. In addition, the researchers will *not* attempt to answer whether the DoD should implement passive RFID in the near future, since the decision for implementation has already been made (Wynne, 2004). The Department of Defense Concept of Operations for Radio Frequency Identification listed some possible implementation constraints falling into three broad categories, to include organizational, process, and technology constraints (OSD SCI, 2004). The referenced concerns will be included in this review, and analysis on whether the issue should be solved in the near term will be provided. By outlining some of the challenges ahead on the road to implementation, DoD stakeholders can invest the appropriate time, energy, and money to ensure the program's success.

System Architecture

As noted in the last section, the DoD currently maintains over 7,000 legacy logistics systems. The proposed CONOPS intends to utilize at least 5 of these systems. Phasing out existing systems and integrating the remaining systems properly will be a large challenge. For passive RFID to be worthwhile, the new and/or integrated system architecture must provide the real time capability that active RFID brought to the war fighter (AFMC, 2004). For passive RFID data to be meaningful, an Advance Shipping Notice (ANS) must be received by the host system where the passive tag data is read. Without the passive tag data marrying up with the ASN information, the data has no larger context and it is not useful.

Analysis. If DoD chooses to utilize multiple legacy systems without "real time" updates, solving this problem quickly will be difficult.

Fully Developed/Integrated Business Process for RFID

Mr. Coyle stated, "When the logistics processes are matured, it [RFID] will be a money-maker for everyone" (Donnelly, 2004). However, as of the writing of this research, the business processes are certainly not mature. In fact, each of the DoD service components has unique business process and perceived unique requirements (OSD SCI, 2004). The current process is to concentrate on implementing the technology and follow-up with process improvement to ensure the "benefits" of RFID are realized.

Analysis. The extra work solving the business process issues prior to implementation will likely pay big dividends later.

Lack of a World-wide Accepted Standard

Currently the EPC Global standard does not match the International Standards Organization (ISO) standard for passive RFID technology (OSD SCI, 2004; Army RFID CONOPS, 2004). It is essential that one world-wide standard be adopted prior to wide-spread application of passive RFID. EPC Global is working with ISO to ensure the current discrepancy is rectified (AFMC, 2004).

Analysis. World-wide adoption of a single standard is critical to the DoD and others. This problem should be solved in the relatively near future.

Rapidly Changing Technology

The DoD has stepped out to be a leader in the early adoption of passive RFID technology. However, as indicated above, the technology is certainly not mature yet. In fact, the DoD CONOPs published in July 2004 requires the Services to update their active and passive tags when the new Generation 2 tags become available. It could be argued that the Generation 1 passive tags (only hold 64 bits) are not a step up from our current bar coding systems in terms of supply chain integration (AFMC, 2004), although they do save manpower. Generation 2 tags do hold enough information to potentially upgrade DoD's supply chain processes. Organizations that choose to wait until the RFID technology is mature to embark on implementation may save considerable time (updating equipment) and money, but they will miss out on the opportunity to "influence" the direction of the technology. DoD will not wait by the sidelines (Stewart, 2004).

Analysis. It is important for decision makers to understand that early entry into new technology will be more expensive to implement and frustrating to the field level users that are actively engaged in working out the rough edges of the new technology.

Budgeting Constraints

The DoD has embarked on the passive RFID path without fully studying the likely short term and long term implementation costs. There are two parts to this constraint. First, the full costs of DoD implementation are not really known, but IBM has been contracted to help determine the proposed costs (AFMC, 2004). The second part of the constraint is concerned with the return on investment. Passive RFID is a new and promising technology, but what return will the DoD have on their investment in the technology. DoD achieved quite a return on investment, after several years, with the implementation of bar coding. However, DoD's proposed use for passive RFID is actually very similar to the bar coding model. Any increased efficiency must be measured against the Automated Identification Technology (AIT) that bar coding brings the supply chain. The ITV benefits are provided with the active RFID system that is already in existence. The Services are concerned about funding this new initiative. Each Service has different budgetary constraints, the ROI is unknown, and there are no offsets (Navy CONOPS, 2004; OSD SCI, 2004). The Services will be competing for funding with other logistics priorities.

Analysis. IBM's research will soon be complete, so the DoD should have a better initial grasp on proposed costs and benefits. A draft Navy RFID Cost/Benefits Study did not support comprehensive funding at this time (Navy CONOPS, 2004). The DoD should ensure that the benefits of passive RFID combined with active RFID are truly worth the cost over bar coding technology and active RFID.

Doctrine and Training

For any new technology to be effective appropriate training must be accomplished. As the DoD quickly learned in OIF, if the troops are not trained to use the new technology under the pressure of battlefield conditions, it will not be effective. Training will need to be an integral part of the implementation process. In addition, developing appropriate doctrine utilizing this new technology is absolutely critical. Services are already concerned about embarking on a new technology without the doctrine and training developed to support it (Army CONOPS, 2004).

Analysis. The DoD must ensure that appropriate doctrine and comprehensive training is established to ensure the success of the passive RFID system.

Other Technology Issues

As with any new technology program, there are numerous issues that need to be worked out for the technology to bear fruit for the organization. Some of these issues are minor and some are a bit tougher to solve. This list is certainly not comprehensive, but it contains a sampling of issues that surfaced during our research that still need to be solved. First, RFID read rates refer to the percentage of tags that are accurately read by the interrogator. It is absolutely critical that the read rate be almost 100 percent. Although the read rates have improved tremendously and anti-collision algorithms have improved enough that over 200 tags can be read simultaneously, the read rates are not 100 percent (AFMC, 2004). For a world-wide supply chain as large as the DoD, this problem needs to be solved for personnel to have confidence in the new system. Second, initial Navy testing on ships has shown some electromagnetic interference with passive RFID readers. Third, can RFID be jammed by the enemy? If so, how can the DoD

overcome this challenge? Finally, are there network security issues that need to be solved prior to full fielding of the technology?

Analysis. Certainly most of the issues above can be solved in due time. Every new technology implementation will have issues that need to be addressed.

Summary

Investigative Question Five attempted to outline challenges to successful integration of passive RFID in the DoD. The list is probably not exhaustive, but it represents many of the larger issues that surfaced during the literature review and interviews with experts. This investigative question served two purposes. First, it helps to ensure that DoD proposed implementation plan is robust enough to encapsulate the identified issues. Second, identification of a comprehensive list of challenges will help ensure management/leadership attention is focused on solving them.

Investigative Question Six

What management strategies provide useful inputs for development of a management strategy for passive RFID?

There are nearly as many management strategies as there are projects in this world. This is as it should be as each project has unique characteristics in everything from requirements, timelines, budgets, available technology, organizational culture, competitive strategy, urgency, and literally dozens of other factors. This investigative question sifts through the extensive literature review to find those management strategies that are pertinent to DoD implementation of passive RFID.

Management Strategy Defined

Just as there are nearly infinite possible management strategies, there is a seemingly endless array of definitions of both strategy and management. This research uses the work of Fred Nickols of Distance Consulting. He sums up strategy neatly with the following:

> "Strategy is about means. It is about the attainment of ends, not their specification. The specification of ends is a matter of stating those future conditions and circumstances toward which effort is to be devoted until such time as those ends are obtained" (Nickols, 2003).

Thus, this analysis is primarily concerned with how to get from point A to point B. Point A is the status quo and point B is a fully functional passive RFID system that delivers all the benefits promised. Nickols then continues with strategy's position as it relates to the means and the ends:

> "Strategy is one element in a four part structure. First are the ends to be obtained. Second are the strategies for obtaining them, the ways in which resources will be deployed. Third are tactics, the ways in which the resources that have been deployed area actually used or employed. Fourth and last are the resources themselves, the means at our disposal. Thus it is that strategy and tactics bridge the gap between ends and means" (Nickols, 2003).

Thus, this paper seeks to provide a framework for management to most effectively achieve its goals with respect to passive RFID implementation. This framework and its

associated recommendations are constrained by the goal at one end and the available resources at the other, so all subsequent analysis must take those constraints into account. Finally, Nickols states the following:

> "Strategy is concerned with *how* you will achieve your aims, not with what those aims are or ought to be, or how they are to be established. If strategy has any meaning at all, it is only in relation to some aim or end in view" (Nickols, 2003, emphasis from original text).

This realization is particularly apt for our research as the decision to implement passive RFID in the DoD has already been made and the mandate already passed to our vendors. Given that our ends have been placed before us, it is now our job to determine the best strategy for achieving those ends.

What is the Requirement?

As noted above, to develop a sound strategy, a means to an end, one needs to know what that end, the requirement, is. Different firms may have different desired outcomes from passive RFID implementation; for Wal-Mart, ensuring the customer will always find what he wants on the shelf, for the DoD it also includes strategic and tactical ITV. So, while this analysis looks to develop a strategy for passive RFID, the ultimate goal is cradle-to-grave in-transit visibility.

But what exactly is in-transit visibility? Is it making sure a combatant commander can see how well his units are equipped? Is it providing up-to-date status of ETAs for MICAP parts to a deployed squadron commander? Is it putting up-to the minute location status of a critical asset in the hands of a supply sergeant in a foxhole? Is

it all of these and more? The literature lacks specific descriptions of exactly what the DoD wants when using the term ITV. First and foremost among the requirements for successful IT implementation is a thorough, specific, well-defined set of requirements (Schulte, 2004). Without first publishing specific and thorough requirements for ITV, DoD can not hope to achieve full success with RFID or any other technology.

Business Process Redefinition

DoD and industry experts agree that RFID in general, and passive RFID in particular, has the potential to enable revolutionary advances in logistics. "We Truly Believe that this technology will transform the supply chain" says Lynn Cadell, President, Yellow Technologies (RFID Journal, Feb 17, 2004). Similar verbiage like " . . . a complete redefinition of the supply chain," (Atok, 2003) and ". . . a transformational agent in DoD logistics . . ." (AFMC draft comments) appear throughout the literature. However, simply laying new technology over old business practices is nothing more than a good way to spend ourselves into failure. Revolutionary technologies are useless without the revolution in business practices to exploit them. DoD's experience with active RFID provides a dramatic reinforcement of this maxim. Prior to OIF, the Army had never done tactical ITV, only strategic (Caterinicchia, 2003). It should then come as no surprise that the strategic portion of active RFID enabled logistics movements were a success story, while ITV was again lost over the "last tactical mile." In short, the Army's business practices for strategic ITV were already in place and the new technology merely enabled greater efficiencies. Without establishing new business practices for tactical ITV, no new technology could improve efforts in this area.

In fact, existing technology, if properly applied, contains tremendous functionality for ITV. Bar codes can store all the data needed for tactical ITV (AFMC, 2004). That DoD has not achieved its goals for tactical ITV is not for lack of technology, but for lack of procedures. RFID simply eliminates the line-of-sight requirement that makes bar coding inefficient by comparison. According to AFMC's draft comments to the DoD business rules:

> "Although RFID holds great promise for the Department as a transformation agent, it is not a panacea. Other mature and well established data collection technologies such as bar coding are completely absent from this policy. Rather than focusing on the implementation of a single data collection method, recommend a broader Automated Information Technology policy that encompasses and documents the interoperability of all AIT" (AFMC Draft, 2004).

Thus, as research question four explored where passive RFID fits with active RFID, any DoD implementation policy needs to take into account how passive RFID fits under the overall AIT umbrella.

In fact, the draft DoD Business Rules for Passive RFID in the DoD Supply Chain highlights just how far the DoD has to go in this area. While they focus heavily on the mechanics of tag specifications and data to be carried, there is no mention of what processes must be developed to capitalize on the technology. While the DoD presses forth with the "cart before the horse," again, AFMC has recognized the pitfall as they are ". . . concerned that the proposed policy focuses on the implementation of a still

maturing technology without first addressing the impacts to the supply chain business process (AFMC draft, 2004).

To illustrate one possible consequence, consider what had become an all too common experience. A unit races to spend end-of-year money. As usual, they decide to use the left over appropriations to outfit themselves with new computers. To expend all their funds, they buy more computers than they need, or can set up in a short time. So, while the overworked information management specialist struggles with his daily duties, the computers sit in storage. Many of the computers are not even removed from their packing until their warranties have expired. Any failures are now the liability of the government. Similarly, the DoD has mandated vendors begin RFID tagging goods at the lowest practical level. Even ignoring the ambiguity of the previous sentence (what constitutes the lowest practical level?), there still may be problems. The vendors will most likely pass on the additional costs to the DoD. If business practices remain undefined, the DoD will not be able to capitalize on the data and will pay for something that can not yet be put to use. Add to this all the capital investment in hardware, software, infrastructure, and integration, and the DoD will have expensive data collecting dust.

Frameworks for RFID adoption

Schulte (2004) prescribes eight sequential IT implementation strategy components: requirements, design, selection of technology, costing, procurement resource considerations, build out, user acceptance testing, handoff to operations, and paying the bills. As previously noted, the DoD has not fully defined its requirements, and the design of our ITV network was performed prior to any discussion of RFID in the

supply chain, yet the DoD is at step three, selection of technology. From industry to the federal government, there is agreement that RFID holds great promise, so it may not be premature to select that technology, but as this research develops a framework for passive RFID, it is important to reiterate the need to complete the first two steps for requirements and design to fully exploit the new technology.

Once passive RFID is under consideration, there are five stages to implementation:

1. Education and data collection
2. Feasibility studies and cost analysis to determine return on investment (ROI)
3. Pilot Testing
4. Limited roll-out
5. Scaled implementation leading to company-wide adoption

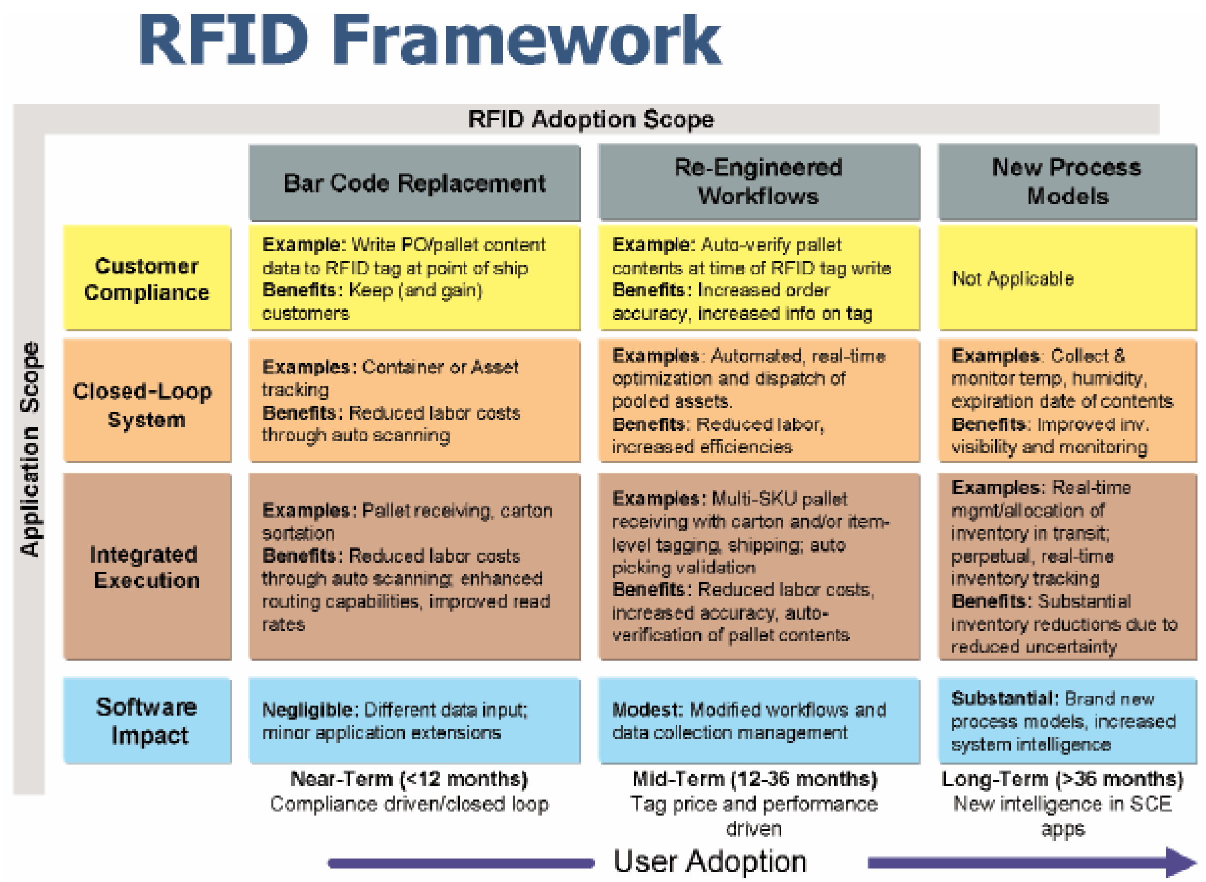
(Bordenaro, 2004)

The DoD made the decision to proceed with passive RFID, including the mandate to industry, prior to assessing the ROI (AFMC, 2004). While ROI-based efficiency is a greater driver in the private sector, given the current fiscal situation, some sort of ROI study could have lent additional credence to the decision to adopt passive RFID. In wartime, DoD's desire for efficiency must give way to the need for effectiveness, and costs become much less important when hostilities must be resolved. However, this decision to move forward reinforces the perception that there is a predisposition toward an exciting new technology: one that could prevent us from applying the necessary rigor to our acquisition and implementation processes.

DoD passive RFID implementation plans phase in capability along two dimensions: locations and type of materiel tagged (Wynne, 2004). Another dimension that should be considered is the functional scope of adoption. For RFID, this functional

scope comes in three phases: bar code replacement, re-engineering workflows, and new process models. According to this model, real-time allocation and management of inventory in transit and real-time inventory tracking are part of the third and final stage.

Figure 8: RFID Framework



(Highjump, 2004)

This framework provides a useful guide for DoD implementation. As noted before, passive RFID provides very similar functionality to bar coding, but with fewer operational restrictions. Since the DoD wants to attach passive RFID tags to materiel at the lowest practical level and bar codes are currently used at a very low level, this makes sense as an early step, especially considering that business practices are in place for much of what bar coding can do. While the DoD takes this first step to become familiar with

the technology and its applications, it could simultaneously develop business practices for full-fledged ITV to eventually marry a more mature technology with a well-defined process.

Funding

Wal-Mart expects to be able to cover their costs of their passive RFID implementation within their normal capital budget (Arner, 2004). Likewise, the DoD has directed the services, under their responsibility to train and equip, to bear the costs of passive RFID implementation. However, there are two key differences between Wal-Mart and the DoD that are worth noting. First, the DoD logistics network is more diverse, and must remain viable in hostile environments, thus driving up costs. Second, Wal-Mart has the ability to push much of their RFID implementation costs on to their suppliers where the DoD may not. No data is publicly available regarding Wal-Mart’s expected total investment in passive RFID, but DoD rough order of magnitude estimates place our estimate in excess of $586 million over the next seven years. Of this amount the USA is responsible for $223 million and the USAF $192 million (Joint Logistics Board, 2004). It may not be reasonable or even feasible to drop a new requirement in the hundreds of millions of dollars on a service and expect them to cover it without additional funding support.

Fortunately, funding difficulties were not an issue for RFID’s cousin GTN. In 2001, the Government Accounting Office conducted an audit to assess the acquisition of GTN. The report looked at compliance with acquisition directives and the overall effectiveness of the GTN acquisition. The report praised GTN in general as a model acquisition program, and specifically noted that funding stability was a key to its success

(GAO, 2001). For passive RFID to be successful, it must have the same funding stability. It is also worth noting, however, that even though GTN followed sound acquisition and implementation models, it has yet to deliver the desired ITV, which is why DoD are now looking at spending another $586 million on passive RFID. This is in addition to another $806 million already spent or allocated to active RFID (Joint Logistics Board, 2004).

Measurement

The private sector measures their success in profit. In most cases it will be difficult to assess how much passive RFID has directly contributed to the bottom line. Similarly, the DoD measures its success in battles won. Again, it will be very difficult to determine just what portion of victories may be attributed to passive RFID. This in no way diminishes the need to measure the impact of passive RFID; this simply means that passive RFID implementation is an activity that cries out for non-financial performance measures.

Consider an anonymous early adopter of RFID technology. They were quite pleased with their new technology, but their customers remained unimpressed. The reason was that the company was defining order fulfillment at the time materiel left their warehouse, but the customer was defining order fulfillment at the time materiel arrived at their door (Andel, 2003). This again reinforces the necessity of assessing passive RFID impact from the perspective of the entire supply chain. Measuring individual pieces of the whole ITV system will lead to costly sub-optimization that bear no fruit for the overall system.

Summary

Investigative question six explored various frameworks that could provide guideposts for passive RFID implementation. It began by providing a working definition for management strategy, stressed the need to fully specify requirements, analyzed three specific frameworks, considered program funding and lastly noted the need to use non-financial performance measures to track the progress of passive RFID success.

Chapter 4 Summary

Chapter four answered each of the six investigative questions in turn. The first two investigative questions described active RFID experience and the subsequent lessons learned. The next two investigative questions analyzed the current and desired state of DoD information management systems and the specific operational and performance parameters of passive RFID. The last two investigative questions looked at potential barriers to passive RFID implementation and applicable management strategies. Having considered previous experience, the current state of the technology, and pertinent management issues, this research is now in a position to provide a management construct and supporting prescriptions for the effective implementation of passive RFID, which will be accomplished in the next chapter.

V. Conclusion and Recommendations

Chapter Overview

This chapter summarizes the research effort. It answers the research question by providing a conceptual framework and specific recommendations for passive RFID implementation. It also assesses the significance of this research and gives recommendations for future research.

Conclusions of Research

Managing any $500+ million program will be a tremendous undertaking. Implementing passive RFID is certainly no exception, especially given that passive RFID is expected to fix a problem the DoD has struggled with for over a decade: inadequate in-transit visibility. To help provide a framework for our management strategy, the following conceptual model for passive RFID implementation is proposed:

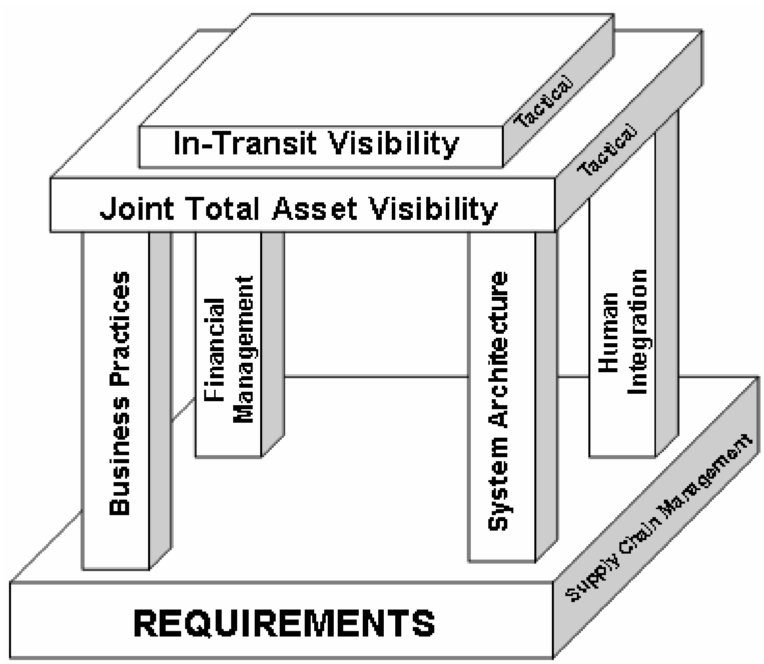


Figure 9: Passive RFID Integration Model

All individual elements of this model as well as their interfaces have been carefully considered for their contribution to a coherent and complete whole and for their reliability as an effective analogy for passive RFID implementation. This conceptual framework begins with a firm foundation upon which four pillars rest. Note that all pillars must be strong, or the roof, which represents the ultimate goal for passive RFID, can not be supported; *if any one pillar is neglected, passive RFID can not succeed in its mission.*

The Foundation: Requirements

The criticality of well-defined requirements has been apparent throughout this research. Without properly defined requirements, any management strategy is likely to end up as aimless wandering; if the DoD finds success, it will be more a stroke of luck than due to the efficacy of any management effort. Consequently, this model places well-defined, complete, specific and readily understandable requirements at its very foundation. Without a firm foundation, no structure can stand—without the right requirements, passive RFID will take the DoD no closer to ITV than the efforts of the previous decade.

The DoD's requirement for ITV is independent of the state of technology, and the first cut at requirements should be written in this way, with the selection of a specific technology to follow, based on those requirements. The research indicates that passive RFID, even if considered anew, without pre-conceived bias, is most likely to be a suitable technology and, if it is indeed the best approach, only then should requirements be

modified to fully take advantage of any other cost-effective enabling qualities the technology may provide.

Pillar One: Business Practices

Only after the foundation of requirements is in place, can the construction of the pillars begin. The first pillar requires the development a complete set of business practices. History teaches quite clearly that new technology, without the proper procedures to exploit it, will be costly and ineffective. In the case of passive RFID, this is far more than just a simple declaration of which items will carry passive tags and which items will carry active tags. This is a complete writing, from the ground up, of all procedures and work flows necessary to achieve ITV. Given that current technology provides the necessary functionality, these business practices need to focus on the foundation, the requirement, not on the technology itself. Using the requirements as a foundation, the business practices need to be written with the current and anticipated state of the technology in mind so as to fully exploit the added efficiencies that may be afforded by the new system.

While the primary motivation for DoD to acquire passive RFID technology has been to facilitate ITV, the literature indicates that both industry and DoD experts expect RFID to revolutionize the supply chain. Again, to fully exploit this possibility, thorough business procedures and redesigned work flows must be developed from the ground up. This development should take into account all of passive RFID's enabling qualities for end-to-end supply chain management to preclude costly sub-optimization. This development requires the DoD to stay plugged in to the world passive RFID community to influence and capitalize on standards. It also suggests collaboration with suppliers, not

only on tagging requirements, but also future possibilities for supply chain savings in the areas of design for production, packaging, and transportation. A narrow approach will lead to an underinvestment in this new technology. To fully exploit the benefits of an integrated active and passive RFID system, the entire supply chain must be considered.

Pillar Two: System Architecture

Of course, for any information technology to be successful, it must also be employed in a system architecture that capitalizes on the data provided and turns it into meaningful information delivered in a timely manner to users and decision makers. One example that neatly ties in the foundation with the first two pillars for a possible success story is the potential integration of passive RFID with the Movement Tracking System (MTS). The MTS is a transponder based satellite tracking system that provides near-real-time location data for equipped vehicles (Carpenter, 2004). Consider a scenario utilizing good, solid requirements for passive RFID with access to ITV location information that is no more than one hour old. Now, apply the lessons learned from active RFID to select DAAS as an intermediary link for passive RFID information to join the GTN database. Recall that DAAS is a superior choice to CMOS because it updated hourly, vice twice daily. After noting the basic requirement, it is apparent that, with passive RFID technology and the right business practices, improvements can be made in asset visibility from one hour old data (via DAAS) to near real time data (via MTS). The ROI justifies the relatively small additional expenditure for the added functionality. While purely speculative, this scenario demonstrates how the proposed model can enhance passive RFID implementation.

Given the history of development of stovepipe logistics information systems, the implementation of passive RFID should be used as an opportunity to step back and assess the feasibility of adding functionality while drastically reducing the over 7,000 systems currently employed. This research was not designed for, nor is it capable of determining if the DoD could possibly reduce the number of Logistics information systems to one a la Wal-Mart. However, this research is adequate to make the assertion that a drastic reduction from the current level would be a good thing. Every consolidation, while costly up front, would reap benefits over time, including reduction in system support costs, training and documentation, and future system integration efforts.

In this conceptual model, system architecture refers not only to IT architecture, but also to all the physical and virtual elements necessary to make the system run. This includes physical infrastructure. This includes buildings, aircraft, ships, trucks, or any other physical asset that may be asked to house or handle passive RFID-tagged materiel. Power sources must be considered, whether land-line, portable generator, or battery. Sources of interference must be determined and mitigated, or workarounds developed. Again, without adequate physical infrastructure, the system architecture pillar can not support the goal.

Pillar Three: Human Integration

As noted in chapter four, an analysis of the potential barriers to passive RFID implementation would constitute an entire thesis unto itself. Indeed, even if the topic was narrowed to human or organizational barriers to passive RFID implementation, it would be a robust research topic unto itself. This does not, however, diminish the importance of integrating the human element into the system, or the need to address it in this research.

In fact, human integration is so important, it constitutes an equally important pillar in the conceptual framework, without which, the goal can not be maintained. Change management, cultural barriers, and organizational behavior must be fully considered in the implementation of passive RFID. These barriers may range from supplier integration issues to levying new requirements on unionized civilian work forces at port activities to inter-service conflicts in deployed areas.

The absolute criticality of one particular element of human integration was made painfully clear by this research: training. When the majority of the deployed force has no familiarity with a technology or its application, there is no hope of reaping its benefits. It was premature to deploy active RFID in theater before procedures had been developed and personnel trained. That error must not be repeated with passive RFID. In today's world of joint operations and expeditionary forces, training of forces is supposed to take place in cohesive units prior to their deployment. So should it be that passive RFID procedures should be exercised by units and practiced by expeditionary forces to the point of familiarity before they are asked to perform in the field.

Pillar Four: Financial Management

Virtually every acquisition program provides lessons learned in financial management; whether positive for stable funding, or negative for disruptive funding. At nearly $600 million, passive RFID will provide a target-rich environment for the budget axe. If RFID is to achieve its promise, it must remain fully funded to the level required by the well-defined requirements mentioned earlier. This means not only hardware, software, and integration, but also documentation, maintenance, and training. Just because the system is acquired and brought on line, does not mean costs go down to zero.

For the funding pillar to remain strong, funding must not only be full, but ongoing to the level the requirement dictates.

Given the equally essential nature of the funding pillar, and the extensive cost of passive RFID implementation, especially to the USA and the USAF, senior levels of management must consider the dangers of expecting the services to fund passive RFID themselves. A new requirement in the hundreds of millions of dollars may get cut to the point of ineffectiveness, or drive the slashing of other service-funded systems to unacceptable levels. In today's fiscal environment, the DoD understands it will never get everything it wants, and may not get everything it needs. Without additional support, it is highly likely that painful tradeoffs will have to be made.

The Summit: In-Transit Visibility

As depicted in Passive RFID Integration Model, TAV and ITV rest upon the four key pillars. If implemented and integrated properly, a fully operable active and passive RFID system as part of a larger, more comprehensive, Logistics Information System will provide tactical and strategic ITV that the Services desire, and the Total Asset Visibility that the war-fighting commanders require. The DoD's current active RFID system has done an excellent job at providing strategic in-transit visibility. In other words, it successfully provides real time ITV from the port of embarkation to the port of debarkation. The breakdown in ITV clearly occurred during the last tactical mile—from the port to the foxhole (O'Brien, 2004). A well integrated active and passive RFID system should bring about the addition of tactical ITV.

Total Asset Visibility is a larger concept encompassing in-storage, in-process, and in-transit visibility (JTAV PMP, 2001). Passive RFID, and the subsequent changes in the

supply chain business processes, will bring about the first two—in-storage and in-process visibility—by providing visibility on assets at the wholesale/supplier level and assets in the maintenance or procurement cycle. Fully functional tactical and strategic ITV combined with fully functional in-storage and in-process ITV will provide the DoD the cradle to grave asset visibility that has been desired since Desert Shield and Desert Storm.

Significance of Research

The literature is completely absent of any information on combining active and passive RFID systems. In fact, no organization, military or civilian, has done it yet. With the largest active RFID system in the world (Stewart, 2004), the DoD is already on the cutting edge with its use of active RFID for world-wide strategic in-transit visibility. In addition, the DoD is focused on the potential capabilities that passive RFID can bring to the organization. Integrating passive and active RFID will either revolutionize the way DoD conducts the supply chain business, or it will merely replace the existing use of bar-code technology. The verdict is still out. The DoD CONOPS for RFID states, "The focus of initial implementations will be more technology oriented, not process oriented. Follow-up may be required to address process enhancements to maximize benefits of RFID" (DoD RFID CONOPS Ver 1.0, 2004, p14). Correctly implementing a world-wide information technology system will require a well formulated strategic plan to ensure success. As Hutchinson et al wrote, "Benefits of RFID can't be achieved on just one application. The technology must be considered across your entire supply chain" (2003; p26). The researchers suggest that the DoD should take a step back from its current

passive RFID implementation plan and take a more rigorous approach. The passive RFID Integration Model is a step toward a comprehensive approach.

Recommendations for Action

Fully define requirements. Any solid plan for strategic implementation of a large scale project requires a thorough understanding of the actual requirements for that system. This research suggests that DoD is marching quickly toward an adoption of new technology without a full understanding on the requirements for the system. To a large degree, this is due to the newness of the technology. Each of the Services has their own logistics processes, multiple legacy logistics information systems, and poor communication with each other. This research suggests that DoD should ensure the complete requirements of passive RFID system are established and agreed upon prior to marching too far down the implementation road.

Fully develop business practices/develop doctrine. Without a fully developed business practice model, the integration of active and passive RFID will certainly not bring about all the benefits that it could. The integration of passive and active RFID has the capability to revolutionize DoD supply chain management, but the current path seems destined for a "quick" adoption of a new technology, rather than a complete change in business practices. To maximize the benefits of RFID, the new business model must be solid. To accomplish this task, the DoD needs to understand how a fully integrated RFID system will change joint doctrine. The doctrine will drive how the DoD trains and equips its forces and maximize benefits of the new capability.

Train like you fight. OIF clearly demonstrated that U.S. forces were not trained to utilize the active RFID technology for which they were equipped. In fact, many of the troops had never seen active RFID prior to being deployed for the war effort. History is replete with examples of why the military must train like it fights. The DoD will need to train troops to utilize RFID in a dynamic wartime environment with enemy on its heels. If the DoD relies on technology to get food and bullets to troops, the troops must understand the importance of the technology and how to use it in less than idea conditions. This research recommends that training programs be developed to maximize the benefits of a fully integrated RFID system.

Maintain stable funding. Stable funding will be critical for passive RFID to implement correctly. Currently each of the Services is attempting to budget to meet the current mandate. As well documented in Chapter 4, the Services are concerned about fighting with no forecasted return on investment or budget off-sets. Passive RFID will have to compete with the many other Service priorities. This research recommends cost benefit analysis be conducted as soon as possible to aid the Services in justifying the expense of passive RFID.

Change Management. If this integration is to be successful, the DoD will to carefully manage the transition. People barriers can derail excellent programs if not properly considered. Poorly stated objectives (Smith, 2004), lack of organizational preparation (Rizzuto, 2003), resistance among personnel (McAfee, 2003), and poor management of the implementation (Rizzuto, 2003) can all contribute to failure of the implementation process. This research recommends that active change management techniques begin now and be utilized throughout the transition.

Reduce the number of Logistics Information Systems (LIS). The DoD should proceed with the fewest number of information systems possible. Large information systems are expensive to maintain and almost impossible to integrate among the services. This is especially important with increasingly joint nature of the DoD's business. All the money spent to date on the thousands of logistics information systems in the DoD should be considered *sunk* costs. Hence, their cost should *not* be considered when deciding whether or not to pursue a single, new logistics information system. For a passive RFID system to work, the Advance Shipping Notice (ASN) must be at the host system where the tag is going to be read. If this doesn't happen, the data is meaningless (AFMC, 2004). It will be much more difficult to get hundreds of information systems to work, than it would be for a single system to operate. Wal-Mart only had 3 information systems and is currently moving to a single system to accommodate passive RFID (OSD SCI, 2004), the DoD would be wise to give this option full consideration. In addition to aiding the implementation of passive RFID, having a single system may solve other problems as well, such as better real time integration of the Time Phased Force Deployment Data (TPFDD) among the Services. Recommend DoD consider funds spent to date on logistics information systems as sunk costs and evaluate the correct course of action within that context.

Establish a DoD Logistics Manager. Coordinating logistics activities across the services is a tough job under the best of situations. As commercial business giants have learned, integration and collaboration among all the members of the supply chain are critical to improving logistics processes in today's world-wide supply chains. The DoD is no different in this matter. Each of the Services has different logistics systems,

different organizational structures for dealing with logistics functions, and their own unique business processes and organizational culture. To facilitate critical efforts at integration and collaboration that are required to form a world-wide supply chain that flawlessly operates in a joint environment; the researchers highly recommend that the DoD create a single Logistics Manager that has command over Headquarters, United States Transportation Command (USTRANSCOM), Defense Logistics Agency (DLA), and Headquarters, Air Force Materiel Command (AFMC), Headquarters, Army Materiel Command. One DoD Logistics boss would help ensure unity of effort and would be able to cut through the Services specific preferences to do what is best for the entire department. Acknowledging that a single DoD logistics manager is highly improbable, a less radical option would be to establish a supply chain integration function charged with coordinating the efforts of military services and their suppliers.

Recommendations for Future Research

The topic area for this research, specifically integrating passive and active RFID, is a new phenomenon, so the door is wide open for future research. The DoD is truly embarking on new and uncharted territory by combining active and passive RFID systems for better ITV and supply chain management. In that regard, almost every topic discussed in the Chapter 4 could be a topic for further research. Investigative Question 5 outlined specific challenges to the adoption of passive RFID within the DoD. Addressing these challenges could easily be a research thesis unto itself. The challenges will need to be solved if the DoD is to reap the potential benefits of an integrated RFID system.

The DoD is proposing a marriage of active and passive RFID to bring about TAV across the supply chain. A future research effort could be to study how best to integrate these two technologies. The DoD is really the first organization to venture down that path, but the DoD's vision for integration may not be the only way, or even the best way, to proceed. This topic certainly deserves attention as many other global organizations will be interested in integrating active and passive RFID, if the DoD is successful.

Although this research pointed out several funding issues, it did not attempt to determine a cost-benefit analysis for passive RFID in the DoD. As previously stated, any benefit in combining active and passive RFID should compared to combining active RFID and bar-coding technology—technologies that are up and running today. Unless the DoD significantly changes their supply chain business model with the implementation of passive RFID, the DoD will not reap many the supply chain efficiencies that could be gained.

In addition, this research proposes a strategic model for implementation of passive RFID in the DoD. This model was based in part on lessons learned from the successful implementation of GeoBase. The GeoBase Sustainment Model proposed by Cullis (2003), revised by Oliver (2003), and validated by Fonnesbeck (2003) served as a starting point for developing the Passive RFID Integration Model. The proposed model is built upon the DoD requirement to provide cradle to grave supply chain management and strategic and tactical ITV. It suggests four pillars—Financial Management, Business Practices, Systems Architecture, and Human Integration—that if implemented correctly will ensure that Joint Total Asset Visibility is finally achieved.   Now that the model has

been proposed, future research should be geared at testing and validating the usefulness of the model.

Other key issues certainly need to be addressed, such as potential security issues with implementation of an active or passive RFID system. In addition, a more technical research could be to determine how to prevent or minimize RFID signal jamming in hostile environments. Another key topic for research would be to determine exactly how few Logistics Information Systems the DoD actually needs. Is one overarching Enterprise Resource Planning (ERP) System with the appropriate additional “bolt-on” capabilities sufficient to meet the DoD’s needs? This topic is of the highest importance to the DoD as it continues to maintain costly legacy systems. When is the right time to stop the piecemeal approach and just start over with a new system that all the Service must utilize?

Summary

This chapter summarized the research effort. It culminated with the proposed model for passive RFID integration, called the Passive RFID Integration Model. In addition, several key recommendations for action were suggested and topics for future research were suggested.

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Appendix A: Interviews

<u>Interview 1</u>

Title of Person Interviewed: DoD Logistics AIT Office

Question 1: *Has/will Wal-Mart/DoD changed its business practices to fully exploit RFID Information? If so, how? At what points will those changes be phased in? Have specific policies and procedures for RFID implementation and maintenance been written and used? If so, is any feedback available regarding their effectiveness/completeness?*

For DoD: The DoD is planning to have a CONOPS, or Concept of Operations, a Supplier Guide and Implementation Guide. Our issue is that the DoD has many more logistics systems than Wal-Mart. Many will go into brown-out (meaning they will cease to be funded) and die within a couple of years. DoD is going with a lot of SAP implementations, especially with the Army, DLA, and Navy. Some SAP applications are ready for RFID now.

For Wal-Mart: Wal-Mart has a rudimentary guide out now. They have changed their business practices. They have made significant progress within their home office, IT department (have 30 plus people on RFID), their DCs and in part some stores. They currently have 3 AIS systems and only one which operates in the U.S. They have already adjusted this system to accommodate passive RFID. They are using it in their Dallas Distribution Center. Eight companies (Gillette, Unilever, Proctor and Gamble, Johnson and Johnson.) are providing Wal-Mart passive-RFID tagged products. The DC has readers on the dock doors. They are still working the advance ship notice that is required for passive RFID systems to work properly. As far as the Dallas Distribution Center: it

has minimal manning and is very well run. Over 1 million people work for Wal-Mart, so they look to save money in manning. The main reason Wal-Mart is pursuing RFID is to stop the out of stocks. They estimate that they lost $8 B in out of stock items in 2002. Their second main reason is shrinkage. U.S. global companies lost $56 B in theft last year.

Question 2: *Did Wal-Mart/DoD run any simulations or models to assess the costs/impacts of RFID implementation?*

DoD: The Services have Title 10 responsibility and must fund RFID in the POM. Initially, it will be funded through working capital funds, then Operations and Maintenance funds.

Wal-Mart: They are placing the cost of tagging on the suppliers. They will not pay for it themselves. Wal-Mart will cover the infrastructure costs inside their DCs and Stores, but not to 100%. Only Some doors and back rooms will have RFID readers.. They are telling companies not to expect a good ROI for three years. They are busy selling the advantages of passive RFID systems to the vendors. As has been widely publicized, Wal-Mart is requiring their top 100 suppliers to comply with passive RFID tags at the case pallet level by Jan 2005. Another 48 companies have already said that they will also comply by that time.

Question 3: *What types of personnel were invited to participate in the development of acquisition and implementation strategy? Were interfaces between Information Technology and Logistics experts created or enhanced? Who has overall responsibility for RFID success?*

DoD: All the services were invited to participate. A DoD RFID experts group was created—mainly out of RFID Vendors and AIDC. OSD Supply Chain Integration Office has overall oversight. Mr Wynne is in charge. DoD must find a way to push data to the services. This will be our Achilles heel. How will you move the data? How will you move the advance shipping notice (called ASN or 856) to marry up the RFID information from the supplier and the distribution center or destination? WAWF and DAASC will play a big part initially.

Question 4: *What has been the experience with vendors so far?*

DoD: Some are complaining, but we keep informing them that in the long run this will help them out. In addition, we inform them that we are only requiring passive RFID at the case and pallet level and only on new solicitations after 1 Oct 2004 and delivering after 1 Jan 2005. In addition, there is a phasing plan with classes of supply, so this is not an insurmountable task. This is really a training issue—vendors need to understand how passive RFID technology will help them.

Wal-Mart: There is some complaining, but more than the required 100 vendors have jumped on the new technology. It is really a training issue to ensure the vendors understand how this will help them in the long run.

Question 5: *How has/will the changes be sold to the rank and file employees? How have training requirements been identified and how will training be accomplished?*

DoD: DoD needs to sell this technology as ITV (In-Transit Visibility)—the real benefit for the Armed Forces. A big advantage for us is that we will be able to divert cargo with TAV, but we have to know where the cargo is.

Wal-Mart: They are showing their people it will benefit them with productivity. They have aligned their performance measures to accommodate this. Wal-Mart's managers at the DC will be evaluated on these new performance measures. They are looking at the big picture.

Question 6: *How was RFID budgeted? Was this method effective? Will vendor implementation costs be absorbed or passed on to Wal-Mart/DoD (i.e. if P&G was selling a case of Tide to Wal-Mart for $10 pre RFID, will that case of Tide will be $10 or something slightly higher)?*

DoD: See above; services must fund themselves—it's the cost of doing business.

Wal-Mart: Wal-Mart will not allow vendors to increase their prices to cover the extra costs that are incurred.

Question 7: *What, if any, enhancements were needed to Wal-mart/DoD's existing IT architecture to fully exploit the benefits of RFID?*

DoD: DoD has over 700 logistics information systems—this will be a challenge to integrate them. Bar coding will not go away for at least 10 to 15 years.

Wal-Mart: Wal-Mart had bar-coding down to an art. They modified one of their 3 logistics systems to handle RFID. It was a Lennox based system so it was easy to adjust it. They are testing it now at the Dallas Distribution Center.

Interview 2

Title of Person Interviewed: Transportation Specialist—USTRANSCOM

Question 1: *Has/will DoD changed its business practices to fully exploit RFID Information? If so, how? At what points will those changes be phased in? Have specific policies and procedures for RFID implementation and maintenance been written and used? If so, is any feedback available regarding their effectiveness/completeness?*

Absolutely, the DoD will change/evolve their business practices. For example, the Fleet Industrial (?) Supply Center (FISC) at Norfolk has choke points to ensure the right items are going into each container. If a "wrong" item is placed in the container, a red light/warning system lets the employee know that he is making a mistake. In addition, the system beeps to notify the personnel that they are getting a "good read". Test bases, such as the FISC, are forming the building blocks on how the business process will work. The DoD is not near ready to write Operating Instructions, yet.

Question 2: *Did DoD run any simulations or models to assess the costs/impacts of RFID implementation?*

IBM is doing a study to determine the ROI. All services put some rough numbers together to meet the current POM cycle. Initial figures are that DoD estimates $750M. The Services are concerned about defending the money to Congress.

Question 3: *What types of personnel were invited to participate in the development of acquisition and implementation strategy? Were interfaces between Information Technology and Logistics experts created or enhanced? Who has overall responsibility for RFID success?*

AMC sent Transportation, Budget, Logistics, and Communications folks to the working group meetings.

The interfaces are TBD. They cannot adequately be worked until Standards and technical architecture requirements are identified.

The Acting Deputy Undersecretary of Defense for Supply Chain Integration Office, under Alan Estevez is responsible for RFID success. Mr. Estevez works for Mr. Wynne—he has ultimate responsibility for the project.

Question 4: *What has been the experience with vendors so far?*

N/A

Question 5: *How has/will the changes be sold to the rank and file employees? How have training requirements been identified and how will training be accomplished?*

FISC Norfolk workers were initially not too receptive, but now they like the RFID initiative. Their throughput has doubled and accuracy has significantly increased. Work activities have changed/shifted, but the worries about job loss did not materialize.

Question 6: *How was RFID budgeted? Was this method effective? Will vendor implementation costs be absorbed or passed on to DoD?*

DoD received PBD (Program Budget Directive) for active RFID to get ahead of the POM cycle, since the active RFID capability was needed for the war effort now.

Question 7: *What, if any, enhancements were needed to DoD's existing IT architecture to fully exploit the benefits of RFID?*

I don't know all the enhancements that are needed. However, when a pallet goes through a receiving port or front gate to a base, you would like the dock personnel to be notified so they can have appropriate equipment (forklifts, etc) and personnel standing to unload the truck when it arrives at the dock.

Question 8: *What lessons can be drawn from the DoD experiences of those engaged in active RFID use that may be applied to our passive RFID implementation?*

The biggest lesson is to look at the entire "end-to-end" supply chain. The theater was not ready to support active RFID at forward points. AIS must be ready to support passive RFID or there is not point in the process. In other words, without the theater being ready to support passive RFID, the information loop is not closed … we don't if the goods made it to the final customer.

Question 9: *What RFID generated information is required at the various levels of management*? No answer provided.

<u>Interview 3</u>

Title of Person Interviewed: HQ AFMC AIT Office

Question 1: *What operational/performance characteristics drive the use of active or passive RFID systems?*

There are several key factors that one must take into consideration when deciding whether to use active or passive RFID systems

1. Cost of tags—active are much more expensive
2. Do you always have connectivity to a host system? You need active tags if you read the data when you don't have connectivity to the host.
3. Distance to read the tags. Active tags, by virtue of having their own power source, can be read from much further away (about 300 feet). Passive tags are read at much closer distances (10 to 20 feet).
4. Do you need the tag to self initiate the communications session, or will the reader always self initiate? If you need the tag to self initiate, then must use active tags.
5. Encryption required? If so, use active tags.
6. In/on/around metal containers? Use active tags.
7. If the system is used for Real Time Location System, then must be an active tag. Luke AFB will be using a RTLS to track location of their AGE on the flight line. Robins AFB uses a RTLS to track gryros in their Gryo shop.
8. Overall, active tags are good for conveyance (on pallets or containers), while passive tags are good on item or box level

Question 2: *What RFID info is required at various levels of management?*

The information requirements are not different from what was required with bar coding systems—management needs the same information as before.

Question 3: *What is your recommendation for the information/systems architecture of the passive RFID system?*

I recommend that we learn a lesson from our successful active RFID system. DoD needs to send all the data to a single server. I recommend that we send all the data through the Defense Automated Addressing System (DAAS). The Advance Shipping Notice (ASN) that is required to marry up with the information on a passive tag should definitely go to the RFITV server. We need to keep the need to keep the number of logistics information systems involved to an absolute minimum. With over 4,000 logistics information systems, this is going to be tough to get where we need to be. The DoD needs to learn a valuable lesson about technology—data integration is the desired end state—RFID is not a panacea. If we don't solve the data integration problems caused by too many logistics information systems, passive RFID will not bring about the desired effects.

Question 4: *How are the standards for passive RFID progressing?*

Currently, there is a problem. The EPC Global standard that everyone will be using is not what the International Organization for Standardization approved. The two organizations are working to solve this issue. We must have *one* world-wide passive RFID standard. It will be fixed in the near future.

Question 5: *How many active tags has the DoD purchased to date?*

Over 600,000 active tags have been purchased to date.

Question 6: *Any other comments?*

What is the *killer* application that RFID is going to solve? If the DoD was to completely utilize the bar code system that they have already purchased for supply chain management activities, they would probably find that passive RFID is not going to bring about much improvement. In fact, a well run bar code system could be married up with active RFID to bring similar advantages that an active and passive RFID system will bring to the fight.

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